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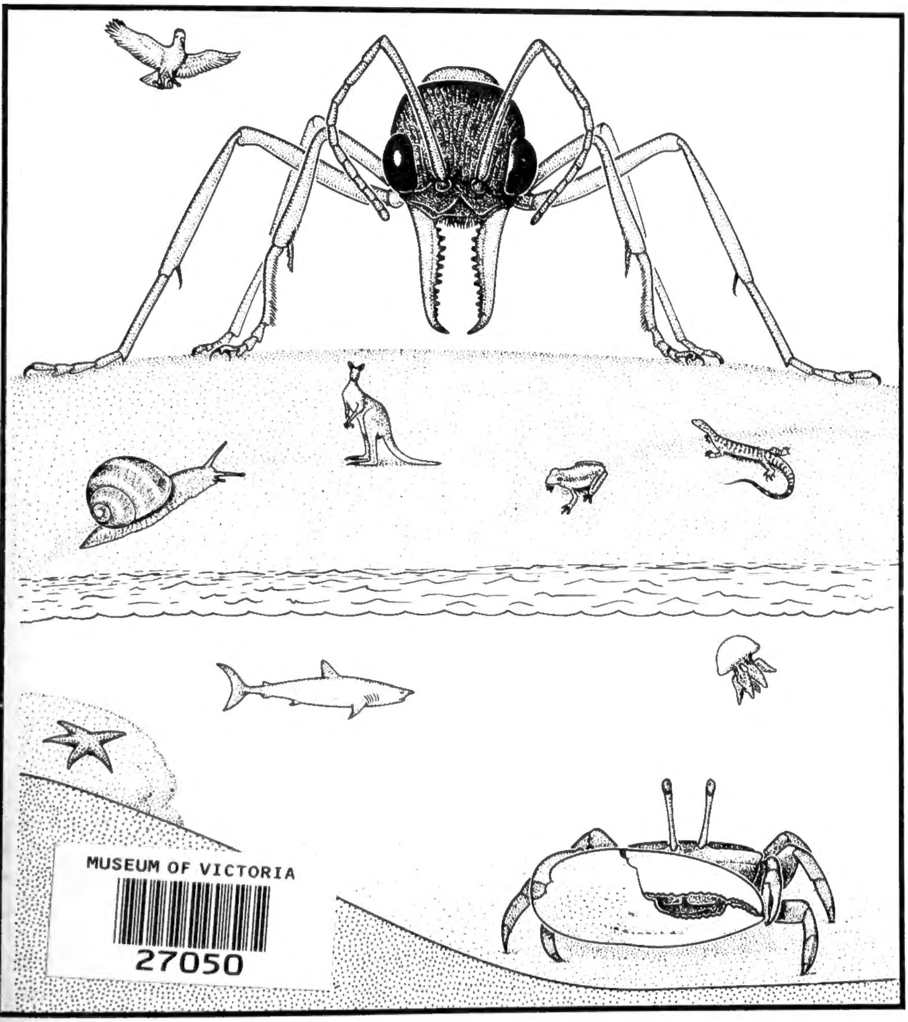
The Victorian Naturalist

Volume 112 (1) 1995 February



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Conservation of Invertebrates

Published by The Field Naturalists Club of Victoria
since 1884

Notice of the Annual General Meeting

The Annual General Meeting of the Field Naturalists Club of Victoria will be held at the Herbarium, Birdwood Avenue, South Yarra,
8 pm, Monday, 10 April 1995.

Agenda

1. Confirmation of the minutes of the previous Annual General Meeting held 11 April 1994.
2. Receipt and adoption of Annual Report for the year ended 31 December 1994.
3. Receipt and adoption of Financial Statements and associated reports.
4. Election of Members of Council.
5. Election of Office Bearers.
6. Appointment of Auditors (remuneration to be determined by Council).
7. Any other business of which proper notice has been given in accordance with the Articles of Association.
8. President's Address.

Election of Councillors and Office Bearers

All members of Council and Office Bearers retire annually but are eligible for re-election. Nominations by two financial members of the Club are required for the following positions:

Council

President
2 Vice-Presidents
Treasurer
Secretary
Six other members

Office Bearers

Assistant Treasurer
Editor (*The Victorian Naturalist*)
Editor (The Newsletter)
Librarian
Conservation Co-ordinator
Excursion Secretary
Sales Officer (Books)
Sales Officer (*The Victorian Naturalist*)
Activities Co-ordinator
Publicity Officer

This is your Club. All members are urged to ensure its on-going viability by filling all the above positions with persons willing and able to contribute to activities, functions and the general work of the Club. Arrange a nomination for yourself or encourage some other appropriate member to be nominated.

Nominations should be in the hands of the Secretary before the Annual General Meeting.

Nomination Forms are available from the Secretary, Geoff Paterson, 5716436.

Species-scape

Following the idea of Q.D. Wheeler (1990), Annals of the Entomological Society of America, representations of major animal groups are depicted at a size that reflects the estimated number of species in each group. The dominance of arthropods and the preponderance of invertebrates over vertebrates is clearly evident. Many of the invertebrates should possibly be larger (or some of the vertebrates smaller!!).

Errata Volume 111 (6) 1994

Kate Weindorfer. The Forgotten Partner of the Cradle Mountain Legend

Sally Schnackenberg.

Due to a technical error the numbers referred to in the footnotes were left out of the text. The editors wish to apologise for this mistake and trust this sheet will help.

Footnote	Position in text			
Number	Page	Column	Line	Word
1	227	1	9	Park
2	227	1	43	Kate
3	227	1	44	Valley
4	227	2	10	Fingal
5	228	1	1	grant
6	228	1	5	Launceston
7	228	1	7	Launceston
8	228	1	13	1880's
9	228	1	16	Hobart
10	228	1	20	State
11	228	1	22	miner
12	228	1	26	Annie
13	228	1	28	talent
14	228	1	34	coast
15	228	2	2	Victoria
16	228	2	7	1902
17	228	2	10	Club
18	228	2	12	Naturalist
19	228	2	15	members
20	228	2	17	meetings
21	228	2	21	1905
22	228	2	23	Hardy
23	228	2	24	Kershaw
24	228	2	33	marry
25	228	2	47	time
26	228	2	52	married
27	228	2	52	later
28	229	1	5	Weindorfer
29	229	1	22	Lea
30	229	1	34	logging
31	229	2	35	gone
32	229	2	46	x-rays
33	229	2	46	inconclusive
34	231	1	35	death
35	231	1	39	death

Books Available from FNCV

The Club has, over the years, published a number of books on natural history topics which can be purchased from the Book Sales Officer. It is currently distributing four of these as follows:

'What Fossil Plant is That?' (J.G. Douglas) $12.50
A guide to the ancient flora of Victoria, with notes on localities and fossil collection

'Wildflowers of the Stirling Ranges' (Fuhrer and Marchant) $7.95
144 magnificent illustrations of the spectacular flora of this region

'Down Under at the Prom' (M. O'Toole and M. Turner) $16.95
A guide to the marine sites and dives at Wilson's Promontory with maps and numerous colour illustrations

'A Field Companion to Australian Fungi' (B. Fuhrer) $19.95
A reprint of the earlier book with additional photographs and changes of name incorporated.

Alan Parkin
Book Sales Officer
850 2617(H) 565 4974(B)

1995 Subscription Rates
(Includes *The Victorian Naturalist)*

Single member	$35
Joint members	$45
Concessional (student/pensioner/country)	$25
Junior (under 18, no Victorian Naturalist)	$5
Other FN Clubs	$35
Institutional subscription	$50
Overseas subscription	AUD $60

Receipts will not be issued unless requested.
Subscriptions are due on 1 January in each year.
Those still unfinancial by April will not receive the journal.

The Victorian Naturalist

F.N.C.V.

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Assistant Editors: Ed and Pat Grey

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Cover: The cover is a 'species-scape' of Australian fauna. Illustration by Graham Milledge (Museum of Victoria). (see facing page for explanation).

Editorial: Why Conserve Invertebrates?

Until very recently, much of the world's limited conservation expertise has focused largely on the needs of vertebrate animals and, to a lesser extent, vascular plants, collectively the most obvious and publicly appealing components of biological communities even though they are numerically minor constituents. One practical exception to this has been butterflies which, because of their unusually high popular appeal amongst invertebrates, have been accepted readily as taxa worthy of conservation. Yet the predominant animals by far in all biological communities are other invertebrates, many of them small, inconspicuous, undescribed and unnoticed by most people. Wilson's (1987) categorisation of these as 'the little things that run the world' awakened widespread realisation that sustaining Earth's natural ecosystems may depend not simply on the well being of a few vertebrate species but, rather, on conserving those myriad less conspicuous organisms whose number, biomass and controlling influences in ecological processes are of paramount importance. More pragmatically, many invertebrates have massive economic relevance to human welfare, be they marine molluscs or crustaceans used as foods, aquatic insects providing early warning of environmental degradation, insects used in crop pollination, or nematode worms acting as natural enemies of forestry pests.

In short, their importance in conservation has two major aspects: (1) as targets, whereby notable species are the focus of major conservation management efforts of the kind familiar in vertebrate conservation, and (2) as tools, whereby change in the incidence or diversity of given taxa may be used to monitor the health of natural communities and indicate the effects of human intrusions. Many invertebrates are far more sensitive than other organisms to such changes.

Invertebrate conservation, essentially the conservation of organismal biodiversity, is an important practical facet of a holistic conservation need, but poses several practical problems. As examples, public images of invertebrates create prejudice against them; their massive diversity means that enumerating taxa to provide inventories for a site or habitat is extraordinarily difficult; many (most) are undescribed and unrecognised, and 'lack of names' is commonly equated to 'lack of interest or importance'; many are short-lived, their biology is unknown, and association of immature stages with adults is difficult; and little is known of the factors which influence their abundance and distributions. Another complex problem is logistics - the lack of sufficient resources, including trained personnel and adequate finance, to undertake the work needed to document invertebrate species and assemblages.

Nevertheless, it is clear that many invertebrates are ecological specialists and are vulnerable to a wide range of threats. The most important is habitat (biotope) destruction on all scales - many invertebrates are highly localised, so that the entire range of some species may be only a few hundred square metres, but others include influence of exotic species, pollution and over-exploitation.

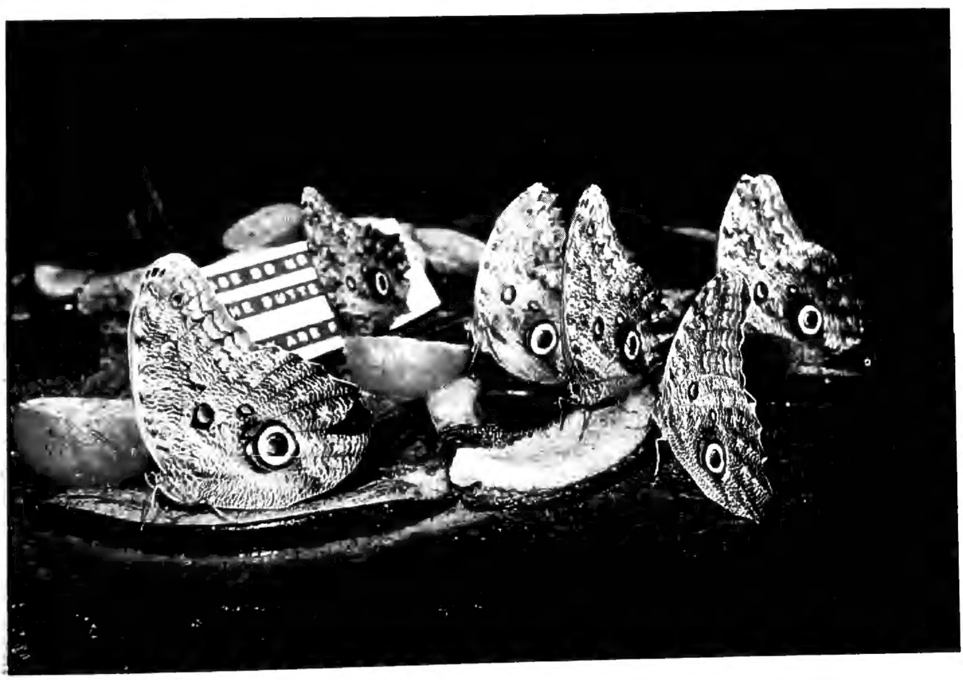
Yet, despite the vast importance of invertebrates in natural ecosystems, their public image, and that of people who study them, has not been good. In the Parliamentary debate on the National Parks Bill in Victoria in 1956, opposition was voiced on the formation of a national park on the Bogong High Plains with the comment '... but where would the State Electricity Commission be if suddenly its works were invaded by 'bug-hunters'? The lerps causing short circuits on the telephone lines would be nothing compared to the damage that would be caused to high-tension lines by Crosbie Morrison's 'bug-hunters'...' (from Graham Pizzey, 1992, Crosbie Morrison - Voice of Nature).

This special issue of *The Victorian Naturalist* summarises some aspects of the needs and practice of invertebrate conservation in Victoria. The first three papers are reviews of needs in terrestrial (Coy), freshwater (Butcher and Doeg) and marine systems (Norman and Sant) to set the scene for later contributions. Major facets in practise include setting priorities amongst species (New), the establishment and function of the pioneering Flora and Fauna Guarantee Act 1988 (Clunie and Reed) and the emotional topic of collecting (Yen and New). The next group of papers indicates the various levels of concern and how these may be translated into practice - from individual species (New), through taxonomic groups (of which butterflies have received considerable attention: Field) to larger units such as communities (Jelinek) and ecosystems, represented here by three contrasting cases: alpine zone (New and Yen), San Remo (O'Hara), and agricultural systems (Horne). Finally, the importance of effective communication in conservation is addressed by Vaughan, Meehan and Yen. We hope that these accounts, necessarily brief, will help to make other naturalists in Victoria and elsewhere more aware of invertebrates and help to remove some of the mystique and suspicions of the relevance of invertebrate conservation.

We thank our colleagues for their contributions to this issue, Graham Milledge for providing the cover illustration, the Editor and Council of the Field Naturalists' Club of Victoria for agreeing so enthusiastically to our proposal, and the Department of Conservation and Natural Resources for their support.

Alan Yen and Tim New

Invertebrates illustrated by John Las Gourgues, and diagrams courtesy of the Department of Conservation and Natural Resources.



Feeding butterflies in UK Butterfly House.

Conservation Status of Terrestrial Invertebrates in Victoria

R. Coy[1]

Abstract

The Victorian terrestrial invertebrate fauna is in most cases poorly known, which gives rise to problems associated with its conservation. A brief description of the Victorian terrestrial invertebrate fauna is provided. Studies of terrestrial invertebrates in Victoria have usually been limited to single species and only recently have been included in faunal surveys. At present 31 species or communities are currently regarded as needing conservation. Possible approaches to the conservation, threatening processes and future needs of invertebrate conservation are discussed.

The relative abundance and diversity of invertebrates

To effectively conserve the biodiversity of invertebrates in Victoria we need to know what fauna is present, what is currently known of the distribution of species and their habitat requirements. Wilkinson (1982) states 'we cannot protect our environment if we do not know its components and how they interact', and New (1984) emphasises the need for 'frequent and emphatic reiteration' of this point.

One theme constantly reiterated in the discussion of invertebrates is the astounding dearth of information on many aspects of the Australian fauna (e.g. New 1984). A major factor contributing to our lack of knowledge is the vast abundance and diversity of invertebrates. The total number of invertebrate species in Australia has been conservatively estimated at 2-300,000 (Greenslade 1985; Richardson 1983, 1984). Approximately 65,000 of these species have been described, classified and named (Hill and Michaelis 1988) and a further 75,000 species have been collected but as yet remain undescribed (Coy *et al.* 1993). In Victoria about 50% of the invertebrate fauna has been formally named (Vaughan, *unpubl. data*). By comparison approximately 5,610 vertebrate species have been recorded in Australia, most of which have been formally described, thus as a conservative estimate about **97 of every 100 animal species in Australia are invertebrates.**

In addition to the lack of taxonomic descriptions for many of the invertebrate groups, the ecology of less than one per cent of Australian insect species has been studied in detail (CSIRO, 1991), and most of these are exotic pest species associated with agriculture and plantation ecosystems, e.g. Neumann and Morey (1983), Clarke (1947), Farrow (1979, 1982a, b). Furthermore, much of the available information is spread throughout a large number of journals, other publications and on specimen labels. The widespread and often obscure information needs to be collated before a comprehensive list of Victorian invertebrate species and their distributions can be compiled.

Considerable information is available in *The Victorian Naturalist* and 'The Victorian Naturalist Subject Index 1884-1978' (FNCV 1979) provides a useful reference system for the articles. The Entomological Society of Victoria maintains an ongoing scheme, ENTRECS, for collection and collation of data on Victorian insects. This type of collation is extremely time consuming and is generally left to amateur enthusiasts and dedicated naturalists. For example, it took many months of dedicated work to collate the distributional data of one of the 114 families of beetles held at the Museum of Victoria (Burns and Burns 1992).

Terrestrial invertebrates as a component of the Victorian fauna

The majority of non-marine invertebrates are terrestrial, at least for part of their life cycle. There are representatives in all the major invertebrate groups in-

[1] Museum of Victoria, 71 Victoria Cres, Abbotsford, Victoria 3067.

cluding protozoa and other microscopic organisms, annelids (worms), molluscs (snails and slugs), onychophorans (velvet worms), myriapods (centipedes, millipedes, symphylans and pauropods), crustaceans (e.g. slaters, land hoppers, land yabbies), collembola (springtails), insects and arachnids (e.g. spiders, scorpions, pseudoscorpions, harvestmen).

Annelids, particularly earthworms, are important to the agricultural industry (Lee 1983). However, research has primarily been restricted to those species occurring in agricultural lands and much of the native fauna is poorly known. Dyne (1984) and Van Praagh (1994) have studied the giant earthworms (Megascolecidae) and Jamieson (1981) discusses the conservation of native earthworm species.

Gastropods (snails and slugs are the only terrestrial representatives of the Mollusca) are of importance to the agricultural and horticultural industries (Smith and Kershaw 1979). Amateur enthusiasts have contributed to our knowledge of their diversity, abundance and distribution. An account of the known species and their distribution is summarised by Smith and Kershaw (1979). Many native species are endemic to Victoria (Smith 1977).

Myriapods are abundant in many terrestrial habitats, especially in forest floors. Millipedes are responsible for the physical breakdown of much of the litter while centipedes and symphyla are predatory. Some information is available on a limited number of species (Mesibov 1986) but virtually nothing is known of the smaller symphylans and pauropods. In a study of Mountain Ash forest litter, the pauropods were among the more common taxa in soil core samples (Coy 1991).

The Crustacea is an extremely diverse class but relatively little is known of the taxonomy and ecology of most terrestrial species. Relatively few have invaded terrestrial habitats but amphipods and isopods are common members of the soil and leaf litter fauna in Victorian forests (Coy 1991).

Economic importance and aesthetic appeal have promoted research on some invertebrate taxa. The ***Insecta*** is the most diverse invertebrate class and all Australian orders are reviewed by a variety of authors in CSIRO (1991), but much of the specific information is only available in specialist publications, for example, Isoptera (Watson and Abbey 1993); Blattodea (Mackerras 1965, 1968); Orthoptera (Marks 1969; Key 1978, 1991; Rentz 1985, 1993); Hemiptera (Moulds 1990); Lepidoptera (Common and Waterhouse 1981; Moulds 1977; Common 1994; D'Abrera 1974); Coleoptera (Zimmerman 1991, 1994); Hymenoptera (Andersen 1991). The most thoroughly known group in Victoria is the butterflies (e.g. Common and Waterhouse 1981), although substantial areas of the state have not been surveyed (New 1984). Much of the information available on this order has been gathered by amateur entomologists. The information on other Victorian orders and species tends to be reported as part of an Australian perspective and information limited specifically to the Victorian insects is restricted.

Victorian terrestrial ***arachnids*** include the spiders, ticks, mites, scorpions, pseudoscorpions and harvestmen. Their diversity, abundance and distribution has been reviewed by a number of authors (Main 1976, 1981 a, b; Davis 1986; Koch 1977, 1981; Harvey 1981, 1985).

The diversity and abundance of each invertebrate group is not reflected by the amount of research afforded to the group, rather economic importance, aesthetic appeal and accessibility have driven research priorities. For example, a recent assessment of the distribution of the Victorian butterfly species (Entomological Society of Victoria 1986) showed that the pattern of distributional data recorded followed major access routes and towns rather than a complete or even coverage of the State.

Studies of terrestrial invertebrate fauna in Victoria

Much of the work on terrestrial invertebrates in Victoria is limited to single species or a small number of species (e.g. Horne 1992; Edwards 1993; Van Praagh 1994). The butterflies have received particular attention (e.g. Vaughan 1988; Crosby 1987, 1990; Jelinek 1991) resulting in a disproportionate representation on listings of species requiring conservation effort. Their conservation is more fully discussed by other authors in this series. There remains an urgent need for the information on single species to be collated and presented in an easily accessible form such as that prepared by Smith and Kershaw (1979) for the non-marine molluscs and by Common and Waterhouse (1981), Dunn and Dunn (1991), New (1991) and Britton and New (1992) for the butterflies.

In most ecosystems, invertebrates are the major faunal component in terms of biomass, diversity and abundance but until recently invertebrates were not included in most faunal surveys (e.g. Norris and Mansergh 1981; Westerway *et al.* 1990). As invertebrates have gained recognition, especially for their importance in ecosystem functioning and conservation, fauna surveys of various ecosystems have included invertebrates (e.g. Yen *et al.* 1989). Some attempts to include invertebrates in faunal surveys were limited by sampling design and the taxonomic level to which specimens were identified (e.g. Loyn *et al.* 1981).

Current surveys concerned with terrestrial invertebrate communities and their conservation in Victoria include: an assessment of invertebrates in threatened habitats - Western Basalt Grasslands (Yen *et al.* 1994; Australian Heritage Commission); an assessment of possible invertebrate indicators of remnant woodland with varying disturbance levels (Museum of Victoria, *unpubl. data*); a study of the impact of forest management operations on ground dwelling Coleoptera in the forests of East Gippsland (Museum of Victoria, *unpubl. data*), and monitoring studies of the Mt Piper butterfly community (Department of Conservation and Natural Resources). Although these studies are not limited to single species they examine only selected groups of the enormous array of terrestrial invertebrates present.

A report on the conservation status of non-marine invertebrates in Australia, which covers many points relevant to the conservation of Victorian terrestrial invertebrates, is currently being prepared (Yen and Butcher 1994), and invertebrates are now to be included in the Atlas of Victorian Wildlife (Department of Conservation and Natural Resources).

Conservation listings of terrestrial invertebrate species and communities in Victoria

Ecofund Australia (1986) provides a list of Australia's threatened invertebrates and the IUCN (1983) lists two Victorian terrestrial invertebrates. Hill and Michaelis (1988) lists 260 invertebrate species worthy of investigation, of which 18 are Victorian terrestrial invertebrates. CNR (1993) lists five endangered, nine vulnerable and one suspected rare, vulnerable or endangered terrestrial invertebrates in Victoria. Eight terrestrial invertebrates or invertebrate communities in Victoria are listed under the Flora and Fauna Guarantee Act 1988, and three sites of significance in Victoria based on terrestrial invertebrates have been proposed to the National Heritage Commission for listing on the National Estate. Most of these listings involve the same species and in total 31 species and one community of terrestrial invertebrates in Victoria are listed in these documents.

Approaches to the conservation of terrestrial invertebrates in Victoria

The conservation of invertebrates has been regarded as an adjunct to vertebrate or plant conservation and no reserve in Victoria has been established primarily for the conservation of invertebrates (New 1984). It was considered that if plant and vertebrate animal species were adequately reserved and protected, the majority of invertebrate species would also be adequately protected. Wagner and Graetz (1979), disagreed and commented that '... generalisations based on the more numerous vertebrate studies may not be applicable to the great variety of invertebrate forms.' A variety of approaches to the conservation of invertebrates has since developed and are discussed in New (1984) and Yen and Butcher (1994). A summary of each approach and its application to Victorian terrestrial invertebrate fauna is presented here.

1. Species approach

The majority of invertebrate conservation proposals are based on single species, and are strongly biased toward the better known taxa. There is sufficient information and evidence to suggest that certain species in Victoria have declined, either in abundance or distribution, and are now potentially under threat, for example the Eltham Copper Butterfly. Most single invertebrate species considered as requiring conservation are specialists (New 1984) with particular or restricted habitat requirements. In these circumstances the single species approach to conservation has provided at least interim protection.

Given the enormous diversity of invertebrates in Victoria and our lack of knowledge of the majority of species, the species approach to invertebrate conservation has serious limitations. Comprehensive baseline studies of the terrestrial invertebrates were not carried out before large scale clearing operations modified much of the Victorian environment, therefore the loss of species or depletion of abundance since the arrival of Europeans cannot be fully assessed. Rarity may also be an artefact of incomplete distributional data. Species which occur in low numbers but are widespread may erroneously be regarded as rare, conversely rare species may be completely overlooked.

2. Community approach

The study of various terrestrial invertebrate communities in Victoria has exemplified the importance of conserving whole communities. The community approach to conservation recognises unusual assemblages of relatively common species. Often rare or restricted invertebrates are included in these communities. Furthermore, the reliance of some rare species on the presence of more common species affects the development of effective management policies. One terrestrial invertebrate community in Victoria, the Mt Piper butterfly community, has been recognised as requiring conservation action and management plans are directed toward conserving the entire, functioning community. Any invertebrates within the community will benefit from the community conservation approach whether it has been specifically identified or not. The major limitation of the community based approach is that a comprehensive list of invertebrate communities and their distribution is not available.

3. Habitat approach

The most effective approach to terrestrial invertebrate conservation is that based on the conservation of habitat (New 1984; Hill and Michaelis 1988; Greenslade and New 1991; Watson *et al.* 1991). Key (1978) points out that even small areas of indigenous flora subject to occasional disturbance can be a valuable refuge for insects that have been completely eliminated from the adjacent paddocks.

The most serious limitation of the habitat approach to the conservation of terrestrial invertebrates is the recognition of discrete or representative habitats. The vast diversity and abundance of terrestrial invertebrates, and their individual relationship with other components within the environment, ensures that any habitat is likely to support a unique community with more localised and rare species than widespread and abundant ones (New 1987). Habitat identification based on vegetation associations implies that invertebrates distinguish suitable habitat on the basis of which plants or plant associations are present. Yen *et al.* (1989), and Friend and Williams (*unpubl.*) found that invertebrate assemblages did not coincide with vegetation communities but may be more reliant on the substrate. Any network of reserves that are selected solely on vegetation attributes will be deficient for invertebrates (Greenslade and Crawford 1994). Similarly, habitat identification based on vertebrate communities was equally poor in predicting invertebrate communities (Yen 1987). The conservation of invertebrates must be planned separately to that for plants and vertebrates and should be based on invertebrate habitat requirements (Greenslade and Crawford 1994).

4. Limiting threatening processes

Limiting threatening process within all environments or habitats, although difficult to implement, is an effective means of conserving the diversity and abundance of terrestrial invertebrates. This approach would entail a major change in the attitude of both the authorities and the public, particularly in assigning values to terrestrial invertebrates.

A number of threatening processes affecting the survival of terrestrial invertebrates have been identified. The greatest threat to terrestrial invertebrates in Victoria is habitat destruction and alteration. The habitat of over 60% of the State has been subject to severe modification, with 99% of the grasslands (Yen *et al.* 1994) and over 65% of forests being eliminated or severely altered (Woodgate and Black 1988). Agricultural practices, in particular the pastoral and cropping industries have been responsible for the majority of habitat destruction, modification and fragmentation since the arrival of Europeans (Williams 1979; Mucher *et al.* 1988; Greenslade 1992). Forestry, urbanisation, industry and mining also cause widespread habitat destruction and modification.

The ongoing spread of exotic species continues to threaten native habitats. Introduced herbivores have caused severe habitat modification (Ratcliffe 1947; Rolls 1984; Williams and Calaby 1985; Pickard 1994; Greenslade and Crawford 1994) and competition with invertebrate herbivores for resources. Other introduced animals cause disruption to the delicate balance of a functioning ecosystem. The introduced European wasp *Vespula germanica*, is a scavenger and a predator of other invertebrates and its effect on native invertebrate survival is unknown. Spradbery and Maywald (1992) noted several square kilometres in Tasmania where many wasp nests were located and no other insects could be found, implying that *V. germanica* may be seriously reducing native invertebrate distribution. Introduced plant species also modify the habitats they invade and reduce suitable habitat for native invertebrate species (Greenslade and Crawford 1994).

Other threatening process include widespread and indiscriminate spraying of pesticides, application of fertilisers (King *et al.* 1985), accumulation of pollutants in the environment, alterations to fire frequency, fuel (litter and log) reduction, alteration to drainage patterns, over collecting, soil compaction and possible climatic changes (Busby, 1988). These threatening processes are more fully discussed in New (1984).

Future direction for conservation of terrestrial invertebrates in Victoria

There remains an urgent need for the collation of existing knowledge and gathering of further information on all aspects of the Victorian terrestrial invertebrate fauna. This collated and improved knowledge is necessary for the identification of species, communities and habitats which are currently under threat, those which will become threatened if current conditions or trends continue, and the threatening processes which need to be ameliorated. Appropriate management priorities can only be based on such knowledge. An understanding of the relationship between species and their habitats is necessary for the effective implementation of habitat based conservation strategies. Information on the relationship between species within assemblages is urgently required before indicator taxa can be effectively utilised in formulating management strategies.

The following suggestions for the future direction of conservation efforts have been proposed by a number of authors including New (1984), DCE (1992), Yen and Butcher (1994).

- development of active conservation strategies based on the habitat approach and limitation of threatening processes to prevent further decline of terrestrial invertebrates. This approach would include strategies directed toward (i) retention of indigenous habitats, (ii) re-establishment of indigenous communities, (iii) minimising unnecessary alterations to the original landscape, (iv) minimising the introduction and spread of non-indigenous species, (v) retention of different components of a habitat e.g. logs, litter and stags, rocks, soil, heterogeneity of microclimate, undergrowth diversity and density, (vi) limit unnecessary changes of regimes e.g. fire and flood, (vii) restrict the indiscriminate use of fertilisers and pesticides.
- collation of existing distributional data into an easily accessible data base, such as the Atlas of Victorian Wildlife (CNR). This will involve the computerisation of data from Museums and other institutions, and the inclusion of reliable data collected by amateurs.
- provide facilities and incentive for training of taxonomists and other specialists to continue the collection and analysis of invertebrate data. Greenslade and Greenslade (1983) noted that a lack of taxonomic work was contributing to the difficulty of identifying invertebrates.
- encourage the production of well illustrated field guides specifically aimed at amateur identification of invertebrates.
- the establishment of sorting centres to coordinate and standardise collection of invertebrates from a wide variety of habitats and to distribute samples to relevant taxonomists for precise identification.
- implementation of educational programs aimed at increasing the public awareness of the importance of invertebrates in the functioning and conservation of ecosystems and as a future resource (e.g. medical, genetic).
- appointment of invertebrate specialists to Government bodies involved in the planning of conservation strategies for the State.

Summary

The Victorian terrestrial invertebrate fauna is diverse and abundant but poorly described. In total, 31 species and one community of terrestrial invertebrates in Victoria have been recognised as requiring attention. This does not reflect the number of species or communities needing monitoring or protection, but rather reflects a lack of collated information on the Victorian invertebrates. The increased awareness of the importance of invertebrates in ecosystem functioning, conservation and as a future resource has led to their recent inclusion in conservation studies and faunal surveys. Species, community and habitat approaches to invertebrate conservation all have attendant strengths and weaknesses, however, the invertebrates of Victoria will increasingly require protection as threatening processes continue to operate. The future survival of invertebrate communities will depend upon the development of a coordinated habitat retention approach which identifies the needs of, and addresses the threats to, terrestrial invertebrates. Research on all aspects of the Victorian invertebrate fauna continues to be of great importance to conservation efforts.

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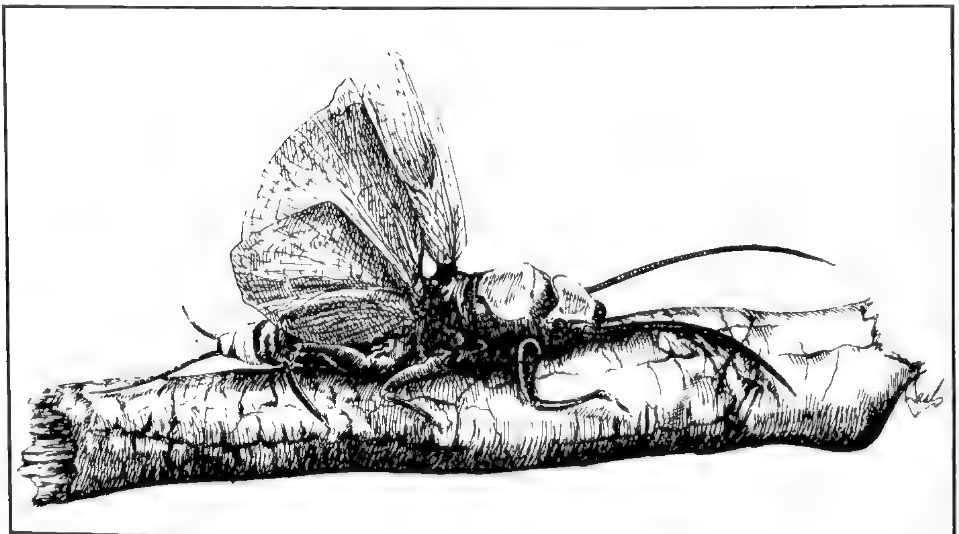

The Mt Stirling Stonefly, *Thaumatoperla flaveola*.

Conservation of Freshwater Invertebrates

R. Butcher[1] and T.J. Doeg[2]

Introduction

There is a highly diverse aquatic (freshwater) invertebrate fauna in Victoria. This reflects the diverse range of aquatic habitats available, from fast flowing erosional upland zones of rivers to slower flowing depositional zones in lowland rivers, deep permanent lakes, shallow swampy country and ephemeral waters. Each of these different types of aquatic habitats has different suites of invertebrate species, adapted to the specific characteristics of the waterbody, in terms of water velocity, depth, physical characteristics such as substratum, vegetation or snags, as well as water quality factors such as temperature, dissolved oxygen and turbidity.

In recent years, recognition of the value of aquatic macroinvertebrates as indicators of the 'health' of aquatic ecosystems (Hellawell, 1986) has led to an expansion of aquatic invertebrate research and through the use of invertebrates, numerous Victorian studies have shown the impact of changes on aquatic ecosystems (e.g. Metzeling *et al.* 1993).

However, while this process may identify predominantly 'natural' sites that have no artificial or human-induced disturbance or detect sites where ecosystem health is declining, it does not necessarily follow that the species or communities associated with those sites are themselves of traditional conservation significance (i.e. are rare, restricted or threatened, or representative). The process of identifying significant aquatic invertebrates is therefore seen as largely different from the identification of ecosystem health.

There are several levels at which aquatic invertebrate conservation strategies can be directed including the species, community, habitat and threatening process prevention level. Each level has distinctive requirements, including adequate taxonomic and distributional data on individual species and communities, criteria for identifying significant habitats, and a knowledge of ecosystem processes.

This paper outlines the current state of knowledge in each of these fields for aquatic invertebrates and evaluates whether sufficient information is available to successfully achieve conservation aims in each of the strategies.

State of knowledge

Taxonomic and Distributional Knowledge

The exact number of aquatic invertebrate species in Victoria is unknown, but is sure to exceed 1000. This uncertainty is derived from both a relative lack of survey effort for aquatic invertebrates, and the poor knowledge of the taxonomy of many groups. Much of the invertebrate identification in Victoria is based on representative collections held by major institutions, where un-named presumptive species are designated with numbers or letters. In one of the largest such collections, there are currently over 600 recognised 'voucher' taxa in the State Water Laboratory's collection.

Taxonomic knowledge of freshwater invertebrates in Victoria is generally poor compared to that overseas (e.g. Merritt and Cummins 1984), but is relatively good for Australia and is increasing. This is a direct result of the growing use of invertebrates in evaluating ecosystem processes and a developing interest in environmental health. A relatively large literature base exists (Hawking 1994) but the available information is largely patchy and incomplete. Part of the problem arises from the particular life cycle of many aquatic invertebrates which involves two distinct phases - an aquatic larva and an aerial adult.

For example, some groups are relatively well known to the species level as adults,

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but can only be identified to the genus level as larvae (e.g. Ephemeroptera). In other cases, keys to the species level of juveniles are available (e.g. the plecopteran key by Hynes (1978)), but have been made largely redundant and inaccurate by subsequent taxonomic reviews that only include adult material (e.g. Theischinger 1984). Concentration on adult taxonomy does not substantially add to the ability to identify the longer-lasting and more frequently sampled larval phases of invertebrate taxa.

Given the high number of aquatic (freshwater) invertebrate species and the poor taxonomic base, the current knowledge of the distribution of species is limited. Only in a few limited cases (such as taxonomic studies noted above) have extensive distributions been established. Until the late 1980s the available data on invertebrates were patchy across the State with only one or two invertebrate studies having been carried out in most of the river basins. Data were also highly variable because of the method of collection and level of taxonomic identification. Of the 28 Victorian river basins only four had significant invertebrate work done on them by 1987 and basins like the Campaspe had no data for aquatic invertebrates (DWR 1989). Most available data were published in separate reports and no effort has been made to consolidate distribution data.

Distributional information, even at the voucher species level, is also hampered by a lack of co-ordination between collections taken by the various groups involved in aquatic macroinvertebrate work. A comparison of voucher species lists from different institutions reveals a variety of different numbering systems, so that a single 'true' species may be referred to differently in different studies, thus obscuring the real distribution of many species.

Single Species Conservation

Due to the above limitations, our ability to identify individual species of conservation significance is severely limited. In Victoria, a total of 23 extant aquatic invertebrates have been identified as endangered, vulnerable or rare (CNR 1993; see Table 1). Another source of information on VROTs (vulnerable, rare or threatened species) is the Flora and Fauna Guarantee Act 1988 (see Clunie and Reed, this issue). Only thirteen of the 24 species in Table 1 and one further aquatic invertebrate (*Spathula tryssa*) are listed under the Act.

Quite clearly, such lists are incomplete. It is hard to believe that only 23 of the potentially thousands of species of aquatic macroinvertebrates are endangered, vulnerable or rare and it is difficult to accept that only one invertebrate taxon has become extinct in Victoria. In part, such a list of VROT aquatic invertebrates reflects the intensity of sampling within only a few groups such as some crustacea (e.g. Morgan 1986) and Trichoptera (e.g. Neboiss 1986).

Additionally, the inclusion of some species on the list may be an artefact of limited distribution knowledge. Where only one or two sites are covered in a particular region during a survey, species that are common and secure, but restricted to a relatively small geographic zone may only appear to have been located at one or two sites, satisfying one of the criteria to be listed as a VROT.

All the above problems are perhaps exemplified by the Otway Stonefly *Eusthenia nothofagi* Zwick. The listing of this species under the Flora and Fauna Guarantee Act 1988 was based on one published record from the type locality (Zwick 1979). At the time of listing, the species had not been recorded from the wild for over 50 years, a formal criterion for declaring the species as extinct. Since listing under the Flora and Fauna Guarantee Act 1988, another confirmed adult was found and CNR (1993) lists the species as endangered due to an extremely restricted distribution (a suitable criterion for listing). However, the species could only be distinguished from the near relative *Eusthenia venosa* as adults, while the more often collected nymphs of each species

Table 1. Vulnerable, rare or threatened aquatic invertebrate taxa in Victoria (from CNR 1993).

Scientific name and status	Common name	Under FFG Act
Extinct		
Austrogammarus australis	Amphipod	Yes
Endangered		
Eusthenia nothofagi	Otway Stonefly	Yes
Hemiphlebia mirabilis	Damselfly	Yes
Taskiria otwayensis	Caddisfly	
Vulnerable		
Engaeus sternalis	Warragul Burrowing Crayfish	Yes
Euastacus diversus	Orbost Crayfish	Yes
Riekoperla darlingtoni	Mt Donna Buang Stonefly	Yes
R. intermedia	Stonefly	Yes
R. isosceles	Stonefly	Yes
Tamasia furcilla	Caddisfly	
Tanjiistomella verna	Caddisfly	
Thaumatoperla flaveola	Stonefly	Yes
Rare		
Archeophylax canarus	Caddisfly	Yes
Boekella nyoraensis	Calanoid Copepod	
Calomoecia australica	Calanoid Copepod	
Engaeus australis	Lilly Pilly Burrowing Crayfish	
Engaeus mallacoota	Mallacoota Burrowing Crayfish	Yes
Engaeus phyllocercus	Narracan Burrowing Crayfish	Yes
Engaeus rostrogaleatus	Strzelecki Burrowing Crayfish	
Euastacus crassus	Alpine spiny Crayfish	
Euastacus neodiversus	South Gippsland Spiny Crayfish	
Thaumatoperla alpina	Stonefly	Yes
T. robusta	Stonefly	
T. timmsi	Stonefly	

were effectively identical. Hence, while *Eusthenia* nymphs had been collected in the Otway Ranges, no other confirmed adults had been found at the time. Recent work rearing nymphs in the laboratory (J. Reed and T. Doeg, Freshwater Ecology Section, unpublished data) suggests that the species may be widespread throughout the Otway Ranges in south-west Victoria.

In the longer term, with an increase in our knowledge base, the number of 'true' VROTs will increase significantly (possibly to hundreds of species based on restricted distributions) and the species approach to conservation will become unrealistic. The value of single species conservation for invertebrate conservation, however, should not be dismissed as there is great potential to utilise selected or flagship taxa to increase awareness of the issues (Yen and Butcher 1994).

Aquatic Invertebrate Community Conservation

Aquatic invertebrate communities have often been used to evaluate ecosystem health. While this work produces community lists from a wide range of sites, the use of this data in conservation work has been limited. There have been no aquatic invertebrate communities identified as having conservation significance in Victoria, and no criteria for identifying such a community are available as yet. Community level conservation, in theory, is a useful tool as it will conserve representatives of the more common taxa as well as rarer or unique taxa. However, considerable research is required before this approach to aquatic invertebrate conservation could be adopted.

Habitat Conservation

Previous and current conservation of aquatic habitats has been centred almost exclusively on wetlands. The identification of significant wetlands is often based on non-invertebrate criteria (mainly plants and water birds). However, the relationship between these classifications based on non-invertebrate flora and fauna in wetlands and invertebrate fauna has not been investigated. Nor has sufficient work been conducted to identify significant wetlands based on invertebrate criteria (either single species or communities). Only one Victorian wetland has been identified as significant on the basis of invertebrates. A swamp habitat for *Hemiphlebia mirabilis* at Tidal River has been registered as a significant site within a National Estate registered area by the Australian Heritage Commission (Greenslade 1994; A. Wheeler, Australian Heritage Commission, *pers. comm.*).

In lotic (continuous flow of freshwater) systems, the Australian Heritage Commission has determined one significant site within a registered area based on the presence of aquatic invertebrates (Parker River and catchment based on the Otway Stonefly). Additionally, two sites have been placed on the interim list (based on *Engaeus sternalis* and the Mt Stirling Stonefly *Thaumatoperla flaveola*) and one site has been nominated and is under consideration (based on *Riekoperla darlingtoni*). While such listings are desirable and valuable (although see discussion above on the Otway Stonefly), the limitations with regard to taxonomic and distributional data noted above suggest that this process based on single species may only identify few of the 'true' sites of significance. Again, as for wetlands, conservation values of aquatic habitat have mostly been assessed using a number of criteria, predominantly land use (agriculture, mining, forestry etc. - McMillan 1990; Meredith *et al.* 1989; Mitchell 1990).

As stated, the identification and conservation of high value aquatic habitats based on land-use or non-invertebrate criteria, while probably conserving invertebrates within the habitat, does not necessarily conserve invertebrate communities or species of conservation significance.

Threatening Processes

Recent aquatic conservation measures in Victoria have concentrated on threatening processes. Under the Flora and Fauna Guarantee Act 1988, it is possible to list threatening processes that have the potential to adversely affect the survival or evolutionary potential of a range of individual taxa or communities. Listed Potentially Threatening Processes (PTPs) that have an impact on aquatic invertebrates are: alteration to the natural flow regimes of rivers and streams; alterations to the natural temperature regimes of rivers and streams; increases in sediment input into Victorian rivers and streams due to human activities; removal of wood debris from Victorian streams and inputs of toxic substances into Victorian rivers and streams due to human activities (preliminary listing only).

Again, such a list is incomplete, partly due to the legal requirements associated with the listing process. Many other activities that have a potential impact on aquatic invertebrates can be found, including: the effect of introduced invertebrate (e.g. *Potomopyrgus*) and vertebrate fauna (e.g. *Salmo* sp), the degradation of riparian vegetation, draining of wetlands, increased stream and wetland salinity, eutrophication, direct exploitation of invertebrates (e.g. crayfish), habitat destruction and long-term environmental changes.

Much is known about the impacts of these processes and ameliorative measures can be suggested for all of them. However, hard data on management options and their effect is relatively sparse and needs to be improved. The successful management of such threatening processes will largely ensure that further degradation of aquatic ecosystems does not occur and, as a by-product of this management, aquatic invertebrates will also be conserved.

Future needs

- A growth in taxonomic studies and intensive regional surveys is required to adequately describe the aquatic invertebrate resources of Victoria, and to identify aquatic invertebrates of conservation significance;
- A central database on aquatic invertebrate information is required, providing access to up-to-date taxonomic and distributional information;
- Coordination is required between the various bodies involved in aquatic invertebrate work to ensure a consistent quality of identification and nomenclature;
- Research into criteria and methods of utilising the community level approach to conserving aquatic invertebrates;
- Research should be initiated into the impact of potentially threatening processes, and especially into the

effectiveness of measures proposed to reduce those impacts. For example, water quality criteria for Victorian environments based on aquatic invertebrates should be accurately determined, rather than derived from overseas data. This must come from wide surveys, with distribution data correlated with environmental parameters or from an experimental approach (e.g. see Doeg and Milledge 1991);

- Evaluation is needed of levels of identification required to monitor conservation targets. The current trend towards identification of samples only to the family level (or higher) needs to be evaluated to ensure that conservation information is not lost. The detection of significant invertebrate communities probably will not be made from family level identifications;
- While considerable resources are expended on studies dealing with invertebrates (and mainly macroinvertebrates) from flowing systems, there is a lack of data on invertebrate communities in wetlands. The effectiveness of classification systems based on plants and waterbirds needs to be evaluated to determine whether those classifications correspond to systems based on invertebrates.

Conclusions

Current information on aquatic invertebrates in Victoria is insufficient for most approaches to conservation. While a few species of conservation significance have been identified, concentration on the single species approach will leave many others open to further decline. No aquatic invertebrate communities of conservation significance have been identified as yet so it would therefore appear that the most likely short term conservation measures will rely on the identification of sites or habitats of high value (using single species, general invertebrate data or land use criteria), or the control of processes that threaten to degrade aquatic habitats. With this dual approach, it can only be hoped that significant species or communities will be conserved until progress outlined under 'future needs' allows them to be identified and targeted with specifically designed conservation measures.

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Conservation Issues for Marine Invertebrates in Victorian Waters

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Abstract

Relatively little is known of the marine invertebrate fauna of Victorian waters. Where surveys have been carried out, these waters have been found to contain a rich diversity of marine invertebrates. In Victoria, a number of invertebrate species is targeted in both commercial and recreational harvests, some forming the basis of multi-million dollar industries. In certain species, heavy exploitation has led to declines in animal numbers and size. Major reviews of management practices for many of the commercial species are currently in progress. Other human activities indirectly exert pressures on Victorian marine invertebrates, including destructive fishery practices, non-collecting visitation pressures, marine and coastal developments, eutrophication from sewerage discharge, siltation, chemical pollutants and introduced biota. Greater information on faunal composition, distributions, ecological relationships and human impacts are required before assessment of the conservation status for the majority of Victoria's species is possible, and appropriate protection regulations can be developed. The value of total protection of defined areas is emphasized as an effective conservation practice.

Introduction

Knowledge of the marine invertebrates of Victorian waters is patchy in nature. Restricted regions, particularly Port Phillip Bay and Western Port, have received considerable attention [see review in Land Conservation Council (LCC) Marine and Coastal Descriptive Report, 1993], while whole sections of the coastline are largely unsurveyed. In areas where surveys have been undertaken, the invertebrate fauna has proven to be rich and abundant: e.g., 700 species in Port Phillip Bay (Poore *et al.* 1975); 350 species off Lakes Entrance (Parry *et al.* 1990); and 600 species at San Remo (O'Hara this issue).

Several works provide an overview of Victorian marine invertebrates (Bennett and Pope 1953, Phillips *et al.* 1984; Handreck and O'Hara 1994). These works recognise the poor state of knowledge of the taxonomy, distributions, biology and population dynamics for the majority of marine invertebrates in Victorian waters.

Few studies have examined the impact of humans on, and conservation issues for, Victoria's marine invertebrates. These studies primarily are reviews of the status of commercially harvested species [e.g., LCC 1993; Kailola *et al.* 1993; Department of Conservation and Natural Resources (DCNR) 1993a] and, more recently, examination of the human impact on intertidal shores (Keough and Quinn 1991; Povey and Keough 1991; King 1992; Keough *et al.* 1993; Quinn *et al.* 1994).

The objective of this paper is to provide a brief summary of the conservation issues relating to marine invertebrates in Victorian waters. The nature of these issues are dependent on the species and the nature of pressures on these animals or their habitats. Victoria's marine invertebrates can be categorised into: directly exploited species; taxa indirectly affected through human activities and localised or remnant species.

Direct human exploitation

Marine invertebrates directly exploited in Victorian waters can be divided into: i) commercial fisheries species; ii) recreational harvest species, and iii) species collected for display, educational or research purposes.

i) Commercial harvests

Commercial harvest of Victorian ma-

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rine invertebrates forms the basis of multi-million dollar fisheries, more valuable than any Victorian finfish harvest. The main commercial species are listed in Table 1 and reviewed in LCC (1993) and Kailola *et al.* (1993). Black-lip abalone (*Haliotis rubra*) is the most valuable fishery, with a landed (first sale) value of around 50 million dollars annually (DCNR 1993b).

Species of the greatest economic value (i.e., abalone, rock lobster and scallops) are targeted by specialised industries. Many of the lower profile species are harvested as bycatch of fisheries targeting finfish or other invertebrate species. Table 1 summarises the fishery type for each commercial species.

As an alternative or addition to wild harvest, a number of marine invertebrates are cultivated by aquaculture in Victoria. Blue mussels form the largest aquaculture industry in Victoria, with production gradually replacing wild harvest. Mussel farms exist in Port Phillip Bay, Western Port, Andersons Inlet and Mallacoota with a first sale value around $880 000 in 1990-91 (LCC 1993). Small scale experimental cultivation of Pacific oyster and abalone also occur in Victoria.

For at least abalone and rock lobster, large-scale poaching occurs along the Victorian coastline. This illegal harvest takes three forms: i) licensed operators exceeding quotas or collecting undersised animals; ii) 'shamateur' operators, masquerading as amateurs collecting legal bag limits and regularly returning to shore to unload catches; and iii) large-scale poaching. In at least the abalone fishery, it is estimated that the scale of the illegal fishery is very large. In New South Wales, the illegal catch of abalone has been estimated to be as much as twice the legal catch (Kailola *et al.* 1993).

The major conservation issues for commercially harvested species are:

i) heavy exploitation/overexploitation;
ii) control of illegal activities; and
iii) developing fisheries.

The perceived status of each marine invertebrate species commercially harvested in Victoria is presented in Table 1. Black-lip abalone, rock lobster and scallops all experience heavy fishing pressure. In the former two species, concerns over regional depletions, decline in catch per unit effort and decreasing animal size have instigated current major reviews of these fisheries and management practices (e.g., DCNR, 1993a, 1993b). The scallop industry is under similar review and, after closure in Port Phillip Bay in 1989-1990, there are encouraging signs of massive recruitment and recovery of this boom-bust fishery in this bay (Smith and Bury 1992).

Indications of overfishing (such as catch decline, localized depletions and decreasing body size) are evident in a number of species. Such trends may have serious implications for the recruitment, and hence survival, of these species and their fisheries. Historically there has been a perception that commercially exploited marine species are protected from biological extinction through economic factors closing a fishery before populations lose viability. With increasing efficiencies in fishing technology, rapidly increasing value of key species (e.g., abalone export prices rising from $7 to $50 per kg, in the shell, between 1979 and 1993, DCNR 1993b) and the absence of detailed data on longevity, fecundity, dispersal, recruitment and mortality rates for the majority of exploited species, it is possible that stock levels for many species may be exploited to below biologically viable levels.

The high scale of illegal harvest, particularly for the most valuable species, is a source of major concern (e.g., DCNR 1993b). Such harvests undermine effective management as illegal operators fail to observe fisheries regulations designed to protect stocks, such as quotas, size limits, closed seasons, protection of females in berry and protected areas.

A number of molluscs and crustaceans not traditionally considered commercial

Table 1. Marine invertebrate species commercially harvested in Victorian waters.
Abbreviations: Fishery type: A = aquaculture, B = bycatch, C = commercial, EA = experimental aquaculture, R = recreational.
Management controls: Com = commercial regulations, rec = recreational regulations; B = bag limit (recreational), EP = experimental permit, F = licence (fee), FP = female protection; G = gear restrictions, L = limited entry fishery, M = minimum size limits, P = protected areas, Q = catch quotas, RF = under regional fishery regulations, S = seasonal closures, Sh = Victorian Shellfish Protection regulations, Z = zoning for licenced operators.
Status: H = heavy exploitation, L = low exploitation.
Other: # = catch statistics back to 1984 only for certain species; ## = erratic catches, figure is average of last 25 years (LCC, 1993); * = main distribution outside Victoria; ** = application to commence fishery current; (+) = possible underestimate, frequently treated in unspecified groupings.
Sources: Catch and Effort, Victorian Fisheries Research Institute; plus Kailola *et al.*, 1993; LCC 1993; DCNR 1993a, 1993b.

Species	Fishery type	Annual catch (max /present)	1990-91 landed value	Management	Status
Blacklip Abalone *(Haliotis rubra)*	EA,C,R	1967-68: 3200t, now: 1440t	$26 million##	Com: L,M,Q,Z; Rec: F,M,B	H
Greenlip Abalone *(H. laevigata)*	EA,C,R	1968-69: 180t, now: ~15t	~1% of blacklip catch	Com: L,M,Q,Z; Rec: F,M,B	H*
Southern Rock Lobster *(Jasus edwardsii)*	C,R	1980-81: 737t; 1993: 474t.	$7.2 million	Com: FP,L,G,M,Z; Rec: F,B,G,M	H
Southern Scallop *(Pecten fumatus)*	C,R	1980-81: -2500t; 1993: 1743t	$7 million##	Com. L,G,S,Z; Rec: B	H
Blue mussel *(Mytilus edulis planulatus)*	A,C,R	wild <:1500t, 1992-93: 112t aquaculture: 1990-91: ~400t	$1.65 million	Com: F,Q; Rec: Sh	L
Southern Calamari *(Sepioteuthis australis)*	B,C,R	1970: 90t; 1993: 43t	$600 000	Com: none; Rec: B,G	L
Arrow Squid *(Nototodarus gouldi)*	B,C,R	1993: 415t	$400 000-800 000	Com: none; Rec: B,G	L
Octopuses *(0. berrima, 0. pallidus, 0. maorum)*	B,C,R	1984: 95 t; 1993: 50t	unknown	Com: none; Rec: none	L
Bait (sand) worms *(primarily Family Nereididae)*	C,R	early 1980's: 30t; now ~10t	$380 000	Com: L,G; Rec: none	unknown
School Prawn *(Metapenaeus macleayi)*	C,R	1984: 44t; 1993: 0.4t, erratic (+)	both spp. ~$300 000	Com: L,S; Rec: AFL,G	H*
Eastern King Prawn *(Penaeus plebejus)*	C,R	1989: 81t; 1993: 0.5t, erratic (+)	both spp. ~$300 000	Com: L,G; Rec: AFL,G	H*
Ghost (or Bass) Yabby *(Trypaea australiensis)*	C,R	1990-91: 1.4t	unknown	Com: L,G; Rec: G	unknown
King Crab *(Pseudocarcinus gigas)*	B,C,R	1993: 208t	~$68 000	Com: L,M; Rec: none	H
Sand Crab *(Ovalipes australiensis)*	B,R	1988:70t(+)	unknown	Com: none; Rec: none	unknown
Purple Sea Urchin *(Heliocidaris erythrogramma)*	C,R	1990: 62t; 1991: ~18t, erratic	unknown	Com: EP,F; Rec: none	L
Balmain Bug *(Ibacus peronii)*	B,C	1992: 19t; 1993: 8t	$2000	Com: VRL,G	H*
Velvet Crab *(Nectocarcinus tuberculosus)*	B,R	1989: 0.07t; 1993: 0t (+)	general crab: $66 000	Com: L, Rec: none	L
Turban Shell *(Turbo undulatus)*	C,R	just started, as in Tas (+)	gen. periwinkles: $8 000	Com: ?; Rec: Sh	L
Sea cucumber *(Stichopus mollis)*	C**	not commenced	not commenced	Com: EP,L,Q,Z**; Rec: none	L
Pacific Oyster *(Crassostrea gigas)*	A	aquaculture: small	$22 500	not applicable	n/a
Periwinkle (unspecified gastropods)	C,R	1992: 18t; 1993: 11t	$8000	Com: none; Rec: Sh	unknown
General Crab (unspecified crabs)	B,R	1992: 11t; 1993: 5t	$66 000	Com: none; Rec: none	unknown

species are receiving an increasing fisheries profile. These developing fisheries include species such as the Turban Shell (*Turbo undulata*) and a range of crabs including the Velvet Crab (*Nectocarcinus tuberculosus*). For such species, either no catch and effort returns are submitted or, at best, catches are reported under headings such as 'periwinkles, general' or 'crabs, general'. Coupled with the paucity of data on distributions, life history, fecundity, dispersal and recruitment for most of these species, there is significant potential for over-exploitation. In species of limited stocks, low fecundity or restricted distributions, over-exploitation could occur before appropriate monitoring and management is put in place.

Current management practices are listed in Table 1 and include:

— Stock assessment, monitoring and collation of catch and effort statistics.

— Direct regulation tools: limited entry fisheries, minimum size limits, closed seasons, gear restrictions, protection of gravid females, zoning, catch quotas, recreational bag limits.

— Industry generated agreements (unlegislated), such as protected areas and seasonal closures.

— Government and industry-funded policing of regulations.

— Protected areas through marine park and reserve systems, and shellfish protection regulations.

A new Fisheries Act for Victoria is currently being developed (DCNR 1994). Structured within this document are provisions to establish Fisheries Reserves, reserves established specifically to protect areas crucial to commercial fisheries (including spawning grounds, juvenile nurseries, critical habitats, aquaculture projects and areas set aside for research and monitoring).

ii) Recreational harvests

Many marine invertebrate species are harvested by recreational collectors from Victorian intertidal habitats and adjacent waters, both legally and illegally. Animals collected for human consumption and/or bait include: chitons (such as *Ischnochiton elongatus, Plaxiphora albida), limpets* (primarily *Cellana tramoserica),* Dog Winkle (*Thais orbita*), Elephant Snail (*Scutus antipodes*), Turban Shell (*Turbo undulata*), abalone (*Haliotis rubra, H.laevigata*), mussels (primarily *Mytilus edulis*), Southern Scallop (*Pecten fumatus*), cuttlefish (*Sepia apama*), octopuses (primarily *O.berrima, O.maorum, O.pallidus*), squid (primarily *Sepioteuthis australis*), Southern Rock Lobster (*Jasus edwardsii*), prawns (*Metapenaeus macleayi, Penaeus plebejus*), Ghost (or Bass) Yabby (*Trypaea australiensis*), assorted brachyuran crabs, assorted worms and the sea squirt Cunjevoi (*Pyura stolonifera*).

The little data available on the scale or influence of this recreational harvest indicate that this it is potentially large. Keough *et al.* (1993) monitored human activity on rocky shores near Melbourne and found high proportions of exploitative activity (25% of visitors actively collecting, despite protection regulations). Comparison of protected areas with unprotected areas also provide indications of the pressures on accessible intertidal and shallow-water habitats. Keough *et al.* (1993) showed significant reductions in size and abundance of three targeted gastropods in exploited areas close to Melbourne compared with protected areas, while non-target species showed no significant differences.

The major conservation issue for recreationally harvested taxa is the heavy exploitation of intertidal invertebrates, particularly on shores close to larger city centres. As a side-effect of the welcome cultural and culinary influences of Asian and European immigrants to Victoria, there has been an increase in recreational/subsistence harvest of a wide range of intertidal molluscs and crustaceans. Interpretation programs, promotion of regulations and appropriate signage have been developed to target and inform key groups.

Current management practices include protection of certain invertebrate species in 'recognized shellfish habitats', primarily intertidal areas. In Victoria, the Shellfish Protection Zone currently extends from Barwon Heads in the west to Venus Bay in the east, excluding several sections on the exposed coast and within Port Phillip Bay. These regulations protect molluscs and crustaceans excluding squid, octopus, cuttlefish, abalone, squirter, pippi, ghost yabby, rock lobster, crabs and sand fleas. Gear restrictions apply for collection of bait species such as sandworms and ghost yabbies from soft-sediment substrata.

iii) Collection for display, educational and research purposes

Collection of marine invertebrates for display, educational programs (through schools, tertiary institutions and marine studies centres) and scientific research also occurs in Victorian waters. People undertaking such activities are required by law to possess a DCNR Scientific Collecting permit. No data are available on the scale of this collection or its influence, however it is possible that such activities may account for the marked reductions in certain intertidal molluscs, such as those reported for the cowrie, *Notocypraea comptoni* and two other gastropod species, *Cabestana spengleri and Pleuroploca australasia,* from certain sites along the Victorian coast (Marine Research Group (MRG), 1994).

Indirect human impact

A wide range of human activities appear to impact indirectly on Victorian marine invertebrates and their habitats. The key categories include:

Destructive fishery practices

A wide range of fishing activities, particularly trawl and dredge fisheries, can cause significant alteration or destruction of benthic habitats. In Victorian bays and inlets, all trawling is illegal. Scallop dredging occurs both within Port Phillip Bay and off East Gippsland. This practice has been suggested to cause damage to sessile invertebrate communities (McShane 1981) and spawning aggregations of the Spider Crab (*Leptomithrax gaimardii*) in Port Phillip Bay (Parry and Currie 1992), as well as potentially releasing heavy metals from soft sediments (Fabris 1981). Current review of the Victorian scallop fishery includes calls for modifications to dredge gear or exclusion of dredging activities from Port Phillip Bay, replacing this technique with diver harvest. Bait pumping in soft sediments can cause sediment disruption, trampling effects and possible heavy metal release (see discussion in Quinn *et al.* 1994).

Non-collecting visitor pressures

A number of non-collecting activities appear to have detrimental effects on Victorian marine invertebrates. Keough and Quinn (1991), Povey and Keough (1991) and King (1992) found that human trampling on rocky shores has a significant effect on algal communities and associated invertebrate fauna. Boat activity and trampling on soft sediment substrata are likely to have similar effects on infauna. Quinn *et al.* (1994) discuss pressures (such as exposure and desiccation) on intertidal biota caused by overturning boulders.

Marine and coastal developments

Coastal development or marine constructions such as marinas (see O'Hara, this issue) can directly affect invertebrate fauna through factors such as direct construction disturbance, dredging, modified or redirected water flow, increased siltation and increases in boating traffic. Watson (in LCC, 1993, pp 86-98) reported changes in invertebrate assemblages in Western Port in relation to heavy boat traffic, through factors such as increased siltation levels and dislodgment of sessile invertebrates from propeller thrust.

Eutrophication

Release of treated and untreated sewerage can result in high nutrient concentrations or 'eutrophication' in marine systems (Axelrad 1978). Boag's Rocks on the ocean side of Mornington Peninsula, Werribee Sewerage Treatment farm in Port Phillip Bay and Black Rock, near Barwon Heads, are the three largest sources of sewerage release in Victorian waters. This high nutrient input can lead to micro- and macro-algal blooms, drastic changes in both algal composition (Manning 1979; Brown *et al.* 1990) and invertebrate assemblages (Dorsey 1982), and the predominance of opportunistic invertebrate species (Dorsey 1982).

Siltation

Factors such as: i) dredging; ii) heavy shipping traffic; and iii) topsoil runoff from rural areas, tree clearing and urban development, all contribute to siltation problems in marine systems (LCC 1993). Heavy silt load is considered detrimental to marine life and has been implicated in the loss of large areas of seagrass and algal cover in Western Port (Shepherd *et al.* 1989), reduced light levels having been suggested as the cause of this dieback.

Chemical pollutants

A wide range of pollutants are released into Victorian waters through industrial outfalls and sewerage systems, including heat, suspended solids, organic wastes, nutrients, non-persistent (e.g., ammonia, chlorine) and persistent toxicants (e.g., heavy metals), and pathogens (see LCC 1993). Such releases are monitored and regulated through the Environment Protection Authority (EPA). All categories are potentially harmful to marine invertebrates, depending on concentrations. Certain persistent toxicants such as heavy metals can cause problems through bioaccumulation, both to invertebrate species and their predators.

Tributyltin (TBT), an anti-fouling agent used primarily on boat hulls, has been recognized as the most acutely toxic substance deliberately introduced into the marine environment (Maguire 1987). TBT causes effects in marine animals ranging from death to severe behavioural alterations and gross mutations of somatic and reproductive tissues. Molluscs are the most susceptible group, often developing male reproductive organs over the opening of the oviduct, effectively preventing spawning. Daly (1990) examined levels of TBT in Victorian waters and found that in 1988/1989 levels in water, sediment and biota significantly exceeded those known to be sublethal to aquatic biota. In June 1989, the EPA introduced regulations limiting the sale and use of TBT based paints in Victoria. A 1990 survey found no significant change in TBT levels in Port Phillip Bay since EPA regulation (LCC 1993).

Introduced biota

In recent years, an increasing number of introduced invertebrate species have become established in Australian coastal waters. In Victoria, these include crustaceans (e.g., *Carcinus maenas, Cancer novaezealandiae*), molluscs (e.g., *Theora lubrica, Musculista senhousia*) and polychaete worms (e.g., *Sabella spallanzanii, Boccardia proboscidea, Styola plicata*) (LCC 1993). Exotic flora and fauna are considered to be carried into Australia in the ballast water of commercial cargo shipping. These species may severely affect native invertebrate species through direct predation, competition and/or habitat alteration. The Northern Pacific Sea Star (*Asterias amurensis*) has recently been introduced from Japan to Tasmanian waters, proliferating in the Derwent River. There are current concerns that this sea star may be introduced to Victorian waters, where there is potential for destructive effects on wild, commercial and aquaculture invertebrate species (O'Hara, Marine Research Group, *pers. comm.*).

Toxic and non-toxic dinoflagellates (such as *Alexandrium catanella, A. tamarense, A. minutum* and *Gymnodium catenatum*) are also thought to have been introduced into Victorian waters via ballast discharge (D. Hill, Botany Dept., University of Melbourne, *pers. comm.*).

Blooms of the toxic algae can directly affect marine invertebrates through physical damage to the gills, oxygen depletion or direct action of the toxins. Wild harvest and aquaculture species can also be affected causing health problems for seafood consumers (LCC 1993).

Recent review of ballast water discharge practices in Victoria (Environment and Natural Resources Committee, Victorian State Government 1994) recommend that untreated ballast water discharge be prohibited in Victorian waters, with all ballast water being treated to eliminate the risk of introducing exotic marine organisms. A range of treatment techniques have been investigated, with heat sterilisation considered to be the most effective and environmentally sound (Bolch and Hallegreff 1993)

Combinations of factors such as those discussed above appear to have contributed to the decline of certain habitat types in Victorian waters. The most dramatic example is that of loss of seagrass beds and associated algae (primarily *Caulerpa* spp.) in Western Port, having declined from approximately 250 sq. km in 1973 to 72 sq. km in 1984 (Shepherd *et al.* 1989). Factors suggested to have led to this decline include blocking of sunlight to seagrass leaves by heavy siltation and excessive growth (and swamping) by epiphytic algae (as a possible consequence of high nutrient input) (LCC 1991).

Localised or remnant taxa

The scarcity of comprehensive data on the invertebrates of Victorian waters restricts discussion of localised and remnant fauna. In regions where detailed surveys have been undertaken, such as Western Port, a number of important invertebrate species have been recognised (see O'Hara, this issue).

The largest known populations of the primitive bivalve, *Neotrigonia margaritacea*, occur in Western Port. This living fossil is the only extant representative of this ancient genus (S. Boyd, Museum of Victoria, *pers. comm.*). Western Port also contains the largest known populations of the lamp shell, *Magellania fluvescens*, a primitive brachiopod (J. Richardson, Museum of Victoria, *pers. comm.*). Both these distinctive species are considered remnant taxa of once widespread forms.

Discussion

As stated above, limited distributional and ecological information prevents assessment of the conservation status of the majority of marine invertebrates found in Victorian waters. For many commercial species, major reviews are currently underway to assess data on biology, stock size and catch, and revise management practices. Underwood (1993) proposed that practices such as bag limits, size limits, or protection of individual species are not ecologically sound, politically achievable and/or possible to enforce. Underwood (1993) and Quinn *et al.* (1994) suggest that the only appropriate approach to conservation of marine flora and fauna and their habitats is total protection of defined areas, excluding all human exploitative pressures including foraging and angling.

Military installations and other sites of complete public exclusion provide clear examples of the value and effect of total protection of defined areas. Keough *et al.* (1993) found that invertebrates on intertidal habitats abutting a rifle range in Williamstown showed significantly greater size and abundance compared with adjacent sites accessible to the public.

Marine parks and reserves currently cover a small percentage of Victorian waters, with some of these parks allowing exploitative activities including commercial and recreational harvests of particular species. The Shellfish Protection Zone covers a large section of the Victorian coastline, however, signage and policing of protection regulations are considered inadequate, enforcement reported as only occurring close to Melbourne and intermittently during peak summer seasons (Quinn *et al.* 1994).

The major requirements for assessing the conservation status of marine invertebrates in Victoria, and developing appropriate protection and management are:

- Increased support of primary inventory surveys, ecological studies, monitoring of human activities in marine systems, and long term monitoring of flora and fauna in impacted sites versus protected sites.
- Direct and effective communication between monitoring/research bodies and management/planning authorities.
- Adherence to objective and independent environmental impact assessments of coastal and marine developments, as well as activities such as dredging.
- Expansion of both the areas and the nature of protection offered in marine parks and reserve systems.
- Increased signage, interpretation, promotion, justification and policing of protective regulations.

These goals should be rigorously sought and promoted in public forums. Both State and Commonwealth governments should continually be lobbied for the necessary commitment and funding to attain these objectives. The authors would also like to stress the importance and value of the watchdog role of both individuals and non-government organisations in monitoring and reporting coastal and marine activities, and their potential impacts on vulnerable biota and habitats.

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Focussing on Species for Invertebrate Conservation

T.R. New[1]

Introduction

Focussing on 'species' or other taxonomic entities as conservation targets is a widespread strategy which has proved enormously useful in practice, especially for rare vertebrates but also for invertebrates such as butterflies, which readily elicit public sympathy. Species can be important tools, as well as targets, for conservation. Programs designed to conserve species benefit many less conspicuous taxa by assuring them of a place to live through habitat protection for the target species. In essence a 'species' is a tangible entity to which people can relate easily, whereas other levels of 'biodiversity' (and biodiversity itself) are more vague. For many biota, the species approach is entirely satisfactory in providing a fine level of appreciation of the need for autecological study as a prelude to management, and for allocating funds and other support precisely. Many local lists and directories, such as 'Red Data Books', cite species in need of conservation assessment or attention and rank them in some order of priority by allocation to hierarchical categories. Especially for invertebrates, such lists can become very long. Nevertheless, they tend to imply moral commitment to practical conservation action.

Problems of focussing on species

Concentrating on species in this way as the major avenue to conservation is expensive. The sheer diversity of invertebrate taxa in need of conservation or which could be included validly on lists of priority taxa precludes this as the main approach to practical conservation. However, such designations are important in drawing attention to the needs of invertebrates and expanding awareness of the scope of organismal diversity and the subtleties of species ecology and conservation requirements. In Victoria, there is no doubt that taxa such as the Eltham Copper Butterfly (*Paralucia pyrodiscus lucida*), the Hemiphlebia Damselfly *Hemiphlebia mirabilis* and the Mt Stirling Stonefly *Thaumatoperla flaveola* have been instrumental as flagships in increasing public and political awareness of invertebrates. But the levels of financial support gained to purchase habitats of the Eltham Copper are unlikely to be replicated even for the relatively few taxa already designated for attention under the Flora and Fauna Guarantee Act 1988. Other than for drawing attention to particular taxa and providing appropriate leads for focussing on species, the practical ramifications of listing numerous invertebrates may be limited simply because of our restricted logistic capability to deal with them. However, the species included on any priority list (the recent IUCN list of Threatened Animals, 1994, includes more than 2000 invertebrate taxa) vary greatly in their needs. Many taxa have been listed in the past on a somewhat *ad hoc* basis, when they have been perceived as threatened in some way, or as the result of the zeal of individual proponents of particular taxonomic groups so that - however deserving the taxa may be - lists may lack objective balance in relation to needs of all invertebrates. Most species have been nominated on the basis of perceived rarity or threat, with little precise knowledge of their status or their role(s) in their respective communities. In some cases, 'local pride' has led to extensive efforts to conserve butterflies threatened in one State or country, but which remain common and secure elsewhere (British butterflies on the edge of a more extensive European range are one example) whereas any local or regional extinction may indeed be important, such efforts may divert resources from species which may be at overall greater risk of loss.

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Priority and ecological values

With only limited resources and support for invertebrate conservation, selection of the optimal use of these is important, and any guidance for some selection of species (however distasteful this and its consequences may be in ethical terms) must be incorporated in helping to help to set priorities. At the extreme, some workers advocate abandoning such fine-level focussing for invertebrates and concentrating entirely on protection and reservation of habitats, with the assumption that taxa living there will continue to thrive. However, experiences in Europe and elsewhere have demonstrated that this may not be so for ecologically specialised invertebrates, for example, butterflies dependent on early successional vegetation which may be lost without regular management.

Focussing on particular invertebrate species can be a strategy to enhance more widespread conservation effort through conserving resources needed by other species. For example, the world's largest butterfly (Queen Alexandra's Birdwing, *Ornithoptera alexandrae*) is listed by the IUCN as 'Endangered' and is a valuable flagship species because of its public appeal. It is also a potent 'umbrella species' - by assuring the security of primary forest habitats in Papua New Guinea on which *O. alexandrae* depends, a multitude of less conspicuous invertebrates also living there are likely to have their chances of persistence enhanced. The butterfly is thereby a 'tool' used to protect vulnerable habitat on which many other taxa depend. Such a species may not itself have a critical ecological role, as a 'keystone' or similar taxon, but there is no doubt that many invertebrates do indeed play key roles in many ecological processes and conservation of ecological capability is an important facet of invertebrate conservation. Species which occupy central roles may influence many others in an assemblage and such important species thus merit strenuous efforts for conservation if they can be recognised. Conversely, a species which may be ecologically 'redundant' (Walker 1992), if such a role exists, is by definition less important.

Attention has also been paid to two other criteria in selecting priority invertebrate species or groups for conservation: (1) their use as indicators or monitors of ecological change and (2) their degree of taxonomic isolation. The first of these, referring either to species or larger taxonomic groups, are those invertebrates whose presence, abundance or distribution reflect changing conditions in the environment and can sometimes provide subtle 'early warning systems' of changes wrought by human interventions. Knowledge of their biology is thus directly relevant to human welfare: a powerful, pragmatic argument for their conservation. Giving priority to taxonomically isolated forms acknowledges the need to conserve the greatest diversity of evolutionary lineages, and schemes for such phylogenetic priority have been discussed by Williams *et al.* (1991), among others. In essence, if a species is the sole representative of its genus, it could be ranked as of more 'value' than a species of a large genus; likewise for higher taxonomic levels (see also Xu Zaifu 1987), so that the greatest overall representation is conserved. On this basis, many subspecies would rank very low; in practice considerable attention is paid to conservation of butterfly subspecies in Australia and in many other countries. Imposition of systems of 'choice' or priority is indeed fickle, and selection of the 'most deserving' taxa a topic of continuing debate.

Discussion

Evaluating the 'status' of an invertebrate to determine its relative or absolute need for conservation incorporates clarifying (1) its taxonomic status, (2) its 'rarity', in terms of abundance, ecological specialisations and distribution and (3) its decline and/or vulnerability to actual and perceived threats. 'Rarity' is an emotive term in conservation and can be defined by many different parameters: it is equated popularly with 'value', and there is some tendency to regard individuals of a common species as less valuable than those of a rare species, an ethically difficult proposition but one which is often true in commercial terms (New 1991). Nevertheless, objective evaluation of degree of threat to a species, as manifest in IUCN Red Data Book categories or some parallel hierarchy to these, is a major guide to conservation need. This selection is a major guide to allocation of our restricted resources.

In the absence of sound quantitative information on invertebrates there can be some tendency to exaggerate the status of a given species by zealous proponents, and this can be extremely difficult to counter. In Victoria, much of the emotion in debate over invertebrate species conservation results directly from differences in opinion (only) over definition of status and the underlying vulnerability of the species. The current IUCN categories of threat are under review (Mace and Lande 1991, Mace *et al.* 1992), and development of objective viable criteria for application to invertebrates is a major practical need. It is at present doubtful whether criteria suggested to quantify risk of extinctions for vertebrates can be applied to most invertebrates, simply because of the difficulties of getting sound information on population structure and quantifying mortality factors.

Even within an invertebrate species, the narrow and sporadic distribution in isolated populations may necessitate comparative study on different sites, as it may be unrealistic to extrapolate from one site to another because of local differences in resources, topography, or climate. It may, however, become feasible progressively to designate ecological correlates of conservation concern. Thus, for butterflies in Britain, the rarest species tend to have one generation each year, have closed populations, overwinter as eggs or larvae, have long-lived larvae with few food plant species, and utilise plants in unproductive habitats (Hodgson 1993). More generally, extinction-prone species have low vagility, are ecological specialists, and have a small geographical range (Spitzer and Leps 1992), so that any of these features may be especially relevant in helping to quantify rarity, and conservation need.

In Victoria, invertebrates from several phyla are listed for priority assessment and conservation under the Flora and Fauna Guarantee Act 1988, with the implication that status assessment and management plans will be forthcoming (Clunie and Reed, this volume). Those nominating additional invertebrates for listing could well consider their rationale for doing so in relation to some of the parameters noted in this paper and designation of priorities for use of highly restricted funding for practical conservation.

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Protection of Invertebrates in Victoria: the Flora and Fauna Guarantee Act 1988.

Pam Clunie and Julia Reed[1]

In Victoria, invertebrates which are considered to be threatened can be listed under the Flora and Fauna Guarantee Act 1988. This heralds a major step forward for invertebrates, because listed items are legally protected; they become protected wildlife under the Wildlife Act 1975. Once listed, the animal immediately has priority for protection and management to ensure its long term survival in the wild. Therefore when nominating invertebrates for listing, it is important to give consideration to the broader context of invertebrate conservation.

Anyone can nominate an invertebrate for listing. The process of listing is summarised by Butcher *et al.* (1994). So far, 22 invertebrates, and two communities described on the basis of the invertebrate fauna, have been listed from a range of groups including worms, marine and freshwater flatworms, crustacea, and insects including stoneflies, damselflies, as well as the inevitable butterflies. Between 80-90% of these items have been listed on the basis of future threats and/or their rarity, while almost a third were eligible because of evidence of decline. Table 1 summarises the range of threats identified for listed invertebrates and the frequency with which they were mentioned. Obviously development and habitat degradation are considered to be the most significant.

Implications of listing invertebrates

When listed, the animals immediately have a priority for protective action. Some of the benefits of listing are that:

- They are immediately protected from 'taking', which includes collecting, selling, disturbing, and so on, bringing them in line with other wildlife under the Wildlife Act 1975. In most cases, this is of dubious value, as direct taking is rarely a threat to invertebrates, especially when compared to habitat loss and fragmentation.
- Action statements, which are brief management plans, must be prepared. These show what has been done and what needs to be done to manage the item and ensure its long term survival in the wild.
- Their habitat can be managed, through actions in an action statement, through agreements with public authorities, and through determining and protecting the 'critical habitat' of that species.
- Surveys and research are concentrated on listed invertebrates. They become a

Table 1 Threats to invertebrates listed under the Flora and Fauna Guarantee Act 1988. (N=22; as at October 1994)

THREAT	%
Habitat Development (includes recreation, land clearance, urbanisation, mining)	54
Habitat Degradation/Alteration	
- alteration of drainage patterns	42
- destruction of riparian vegetation	29
- cattle grazing/trampling	25
- sedimentation	21
- alteration of temperature/flow/light/ turbidity/nutrients	17
- burning/mowing practices	17
- deterioration of water quality	8
- damage to associated items	8
- weed invasion	4
- pollutants	4
- genetic isolation	4
- rubbish dumping	4
- pesticide/herbicide usage	4
Collection	21
Rarity itself	13

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focus for Departmental and Commonwealth funding, as well as often attracting interest from conservation volunteer groups. They provide a focus for grants to landholders e.g. Save the Bush.

- They gain a higher public profile, through such avenues as action statements. The Department of Conservation and Natural Resources (CNR) threatened species brochures, and articles in newsletters or publications including Land for Wildlife bulletins and Australian Geographic.
- They are considered in planning decisions. All sites where listed invertebrates occur are added to CNRs databases, and are therefore available to staff when making land use planning decisions, and when liaising with various public authorities. They are also considered in documents such as LCC reviews and recommendations, and included in lists of values in areas of National Estate.

Achievements following listing

Prior to listing, few invertebrates had extensive monitoring or survey programs, exceptions being the Eltham Copper Butterfly and the Altona Skipper Butterfly, and to a lesser extent the *Hemiphlebia* damselfly and Giant Gippsland Earthworm. Since listing, efforts on these animals have continued, and the number and range of invertebrates being studied has expanded.

Action statements have provided an effective mechanism of summarising past actions and focusing future work. So far, action statements have been published for 25% of listed invertebrates, including the Otway Stonefly, Dandenong Amphipod, *Hemiphlebia* damselfly, Eltham Copper Butterfly and two communities: San Remo Marine Community and Mt Piper Butterfly Community No. 1 (both of which were described primarily on the basis of the invertebrate fauna). In addition, five are currently in various stages of preparation. Recommended actions include survey, rearing, research, public education, community involvement, fire management, and protection of habitat from activities such as forestry, cattle access, or development.

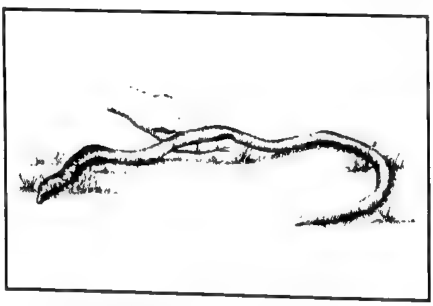
A few examples

The Otway Stonefly is an insect known only from the Otway Range. Prior to listing, it was thought extinct, though shortly after listing its existence was confirmed from two localities. Surveys to determine distribution were identified as a priority in Action Statement No. 45 (Reed and Smith 1993). During 1993/94, with the assistance of ANCA funding, the Otway Range streams were surveyed, and a number of nymphs were retained and reared through to adults, all of which were confirmed as Otway Stoneflies. The species is now known to occur throughout a large area of the Otway Range, including land which is secured in National or State Parks. The issue of delisting the species may need to be considered. Data on the species location will be incorporated on the Department's databases, where it will be available for use in planning decisions.

The Orbost Crayfish occurs in streams in East Gippsland. It is currently known only from public land where forestry activities are the primary landuse. When listed, only one population was known, and only 14 specimens have ever been collected despite extensive surveys of rivers through Gippsland. Departmental staff, and more recently a group of conservation volunteers in close liaison with CNR, have been searching for the crayfish, and it is now known from at least two new sites.

The Alpine Flatworm is a small, white flatworm which lives in springs and bogs in Victoria's alpine and sub-alpine areas. At the time of listing, it was known from only three sites; two on Mt Buller, and one near Mt Howitt. Owing to concerns over future developments in the alpine area, CNR funded a survey in 1993 to determine whether the animal's distribution was indeed this restricted. Representatives of all white flatworm populations were collected and retained for identification (as the species is too small to be clearly identified in the field). The surveys found the species to be more widespread than previously known, though it is still only found in the Mt Buller-Stirling area and the Mt Howitt area (Dr. Ros. St. Clair, *pers. comm.*). However, another white flatworm was found which, despite extensive searching throughout the Alps, appears even more restricted.

The Giant Gippsland Earthworm is patchily distributed over a small area in South Gippsland. The species is now restricted to areas not heavily utilised, such as stream banks and gullies (Yen and Van Praagh 1994). The primary issues regarding its conservation are protection of its remaining habitat from disturbance (such as ploughing), and determining a sustainable level of taking - as animals are currently collected from the wild for part of an educational display. Since listing, CNR resources have been directed into community education to promote the issue of the worm as a threatened species in need of protection, and to explain to landholders how to manage their land to protect worm habitat. This information is largely targeted to landholders through the Land for Wildlife program - there is, for example, a Land for Wildlife Note on worms and their protection. At least two landholders will be helped to protect habitat through the Save the Bush program. Research has provided data for population



The Giant Gippsland Earthworm, *Megascolides australis*.

modelling to determine sustainable levels of taking, and a group is currently working on this issue.

How to use the Flora and Fauna Guarantee Act to best protect invertebrates

Individual nomination and protection of threatened invertebrates is hardly feasible, due to their large numbers, incomplete taxonomic knowledge, and because in general, the fundamental knowledge on how to manage them is not known (though as Murphy *et al.* 1990 note, information useful for the management of some invertebrates, such as butterflies, is available in insect pest management literature, which also seeks to identify factors that regulate populations-though to different ends).

A broader approach to conservation of invertebrates is provided by the ability to list communities and potentially threatening processes under the Act. Management of these is likely to protect a far greater number of species than the single species approach. Management of communities and threats also provides the ability to protect habitat, which is widely accepted as the most effective method of protecting invertebrates (e.g. New 1984 and 1987).

So far, fourteen communities have been listed, and these include examples from grassland, marine, alpine and rainforest habitats. Once a community is listed, all components of that community are protected - which means that the habitat is protected. A community may be described on the basis of the invertebrate fauna, with an example being the Mt Piper Butterfly Community No.1. This community is characterised by an unusually high diversity of butterflies, moths and ants, including several threatened species. However, this is not necessary in order for protection to be conferred on the component invertebrates, which is fortunate given that information to identify and describe invertebrate communities is sparse. Any invertebrate which forms part of a community is protected when part of that community, even if not threatened in its own right. For example, protection of the Western (Basalt) Plains Grassland community will protect the invertebrates which form part of that community. Direction of effort toward identification and nomination of communities important for protection of invertebrate biodiversity would be of great value for invertebrate conservation, whether the communities are described on the basis of the vegetation, the invertebrates, or some other descriptor.

Thirteen potentially threatening processes have been listed, and as a consequence must be managed so that they cease to pose a threat to flora and fauna. The management of many, if not all, has the capacity to protect invertebrates and their habitat. A number of potentially threatening processes already listed, including sedimentation, and alteration to temperature and flow regimes, have been identified as threats to listed invertebrates (Table 1). There are countless processes which pose threat to invertebrates, and nomination and subsequent management of these would be of great benefit to invertebrate conservation.

Conclusion

The Flora and Fauna Guarantee Act 1988 provides a number of mechanisms useful in protection of invertebrates. Listing of individual species has focussed attention and management action on these species, but while useful in many cases, this approach will not be effective for invertebrate conservation as a whole. An increased focus on the identification and management of communities and potentially threatening processes would be of great value in protecting invertebrate biodiversity.

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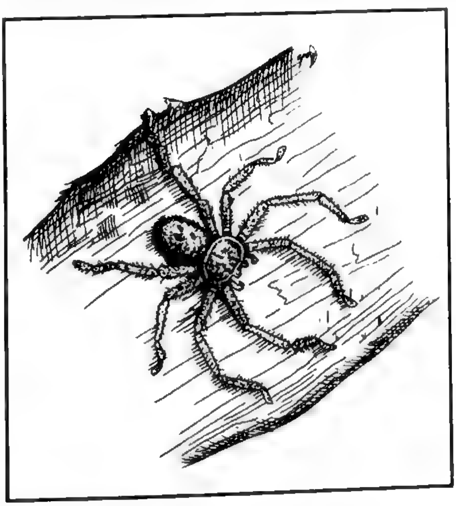
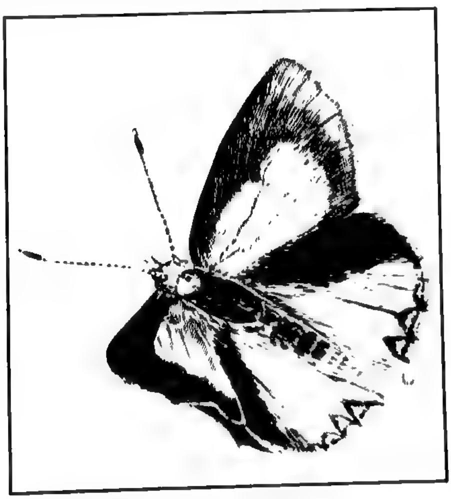


Huntsman Spider.



The Eltham Copper Butterfly, *Paralucia pyrodiscus lucida*.

Is Invertebrate Collecting a Threatening Process?

Alan L. Yen[1] and Timothy R. New[2]

Introduction

Among the great diversity of threats designated for invertebrates, perhaps none arouses more heated debate than 'overcollecting'. The regulation of take has historically been the basis for much of the protective legislation covering invertebrates, and this has resulted directly from the belief that collecting is a major threatening process for invertebrates. This assumption is too simplistic, and has resulted in the 'protection' of some species that are not under any threat, and may have inhibited legitimate and important gathering of information about invertebrates. 'Collectable' species tend to be the larger and more colourful species such as butterflies and beetles, but there is no doubt that rarity can indeed equate with value. Until the advent of the Flora and Fauna Guarantee Act 1988 which fundamentally protects habitat, much of the conservation legislation in Australia was aimed at controlling collecting rather than habitat destruction, and did not acknowledge the several categories of collecting involving different collecting intensities and different target groups. Prohibiting collecting of invertebrate species without protection of their habitat is largely futile, and the actual effects of collecting are questionable when compared to the effects of habitat alteration and destruction.

Types of collecting

Material sought by collectors generally involves collecting at low volume levels. It can involve collecting by amateurs or professionals for taxonomic, biological, ecological or conservation research, collecting for educational purposes (at all levels), or collecting as a hobby. The taxa sought by collectors are primarily butterflies, the more colourful beetles, and spectacular invertebrates such as stick insects and theraphosid ('bird-eating') spiders. Specimens are often obtained by commercial dealers who sell material to scientists, museums and private collectors (Collins and Morris 1985).

The level of commercial trade in native Australian species (predominantly butterflies or beetles) is small, and most of the trade involves imported material. Some Australian species are advertised for sale overseas, although it is difficult to determine the original source of much of the material (Hawkeswood *et al.* 1991).

High volume collecting involves the commodity markets. Large numbers of more common species are collected to be incorporated into curios such as paper weights, cuff-links, brooches, etc. The source of this type of curio market is predominantly Asian.

The greatest volume of collected specimens involves material harvested for food. In Australia, relatively few terrestrial invertebrates are involved, although witjuti grubs and honey-pot ants are harvested by traditional landowners or for tourism. The major food market involves freshwater crustaceans and marine invertebrates. It is important that commercial collecting of these taxa is founded on a scientifically determined ecologically sustainable base and the catch needs to be monitored and controlled if necessary. Mass collecting affects both target and non-target species, and commercial culturing of desired species should be encouraged, as is happening with some species of freshwater crayfish and marine invertebrates.

Arguments against collecting

Decline in populations of target species

Many invertebrate species can withstand a considerable level of harvesting because of their high reproductive capac-

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ity, although there are exceptions. Overcollecting can cause permanent decline to species (1) whose populations are already critically depleted by other factors such as habitat destruction, (2) with small populations of high commercial value, (3) that have a low reproductive rate and low juvenile recruitment (Collins and Morris 1985), or (4) which are limited in their ranges.

Key (1978) could not list any Australian insect species on the Australian mainland that was directly threatened by collecting. More recently, some examples of invertebrates have been found where collecting has been a factor in their decline. For example, due to its limited distribution, its longevity, its low reproductive rate, and its fragile body (Van Praagh 1992), local populations of the Giant Gippsland Earthworm (*Megascolides australis* McCoy) may be threatened with extinction even by a limited amount of collecting (McCarthy *et al.* 1994). There is also evidence of overcollecting causing further decline in the already threatened Bathurst Copper Butterfly (*Paralucia spinifera*) (Dexter and Kitching 1993).

Lack of recognition

There is danger that collectors may be unable to recognise when they are depleting a species below the recovery threshold, especially when they only visit the breeding areas for short periods of time. Many species can reproduce exponentially when conditions are suitable, but they may also decrease exponentially when conditions are poor. For many groups of invertebrates, the large numbers of species within the group means that often a specialist is required to confirm species identification, and a less expert collector may not be aware of the taxa collected.

Non-target species

Large scale or indiscriminate trapping methods are rarely used to collect specimens for the high volume collector market because of potential damage to specimens. Consequently, it is likely that very few non-target specimens are directly affected, although some may be indirectly affected through habitat destruction. More non-target invertebrates are affected in some commercial areas, especially in marine fisheries, where 'bycatch' can be substantial.

Habitat alteration and destruction

Removal of specimens may have deleterious effects upon the local populations of some species, but deliberate or accidental habitat destruction by collectors may reduce the value of that particular habitat for both the target and non-target species. For example, microhabitats may be destroyed in searching for butterfly pupae desirable to rear perfect specimens.

Creating demand

Protective legislation can create illegal trade for collectors, and increase the commercial value of species. In Queensland, *Papilio ulysses* and *Ornithoptera richmondia* are protected, and this has established a black market for species that in some areas have become common garden butterflies where the food plant is grown as a garden tree.

Arguments for collecting

Information gathering

Collecting, by both amateurs and professionals, has built up collections that provide information which is essential for practical conservation today. Information on past distributions and abundances of species is vital in determining whether a particular species has declined. Some of the enormous gaps in our knowledge of the Australian invertebrate fauna will only be filled with the assistance of amateur collections. Similarly in Australia, the life histories of many butterflies and moths has been brought to the attention of the public by dedicated amateurs (e.g. Coupar and Coupar 1992).

Educational benefits

The potential to use invertebrates in environmental education has not yet been fully realised. Collecting can be an instructive and educational hobby, and many people used collecting in their formative years as an important part of their training, in graduating from hobbyist to professional biologist. Without collecting, such recruitment may be severely hampered.

Economic benefits

Commercial collecting can be an important source of income and is not necessarily harmful. Habitat destruction is still the major problem, and the danger is that past sustainable commercial collecting levels will become unsustainable with decreasing habitat areas and quality. Captive breeding can provide high quality specimens to the trade and take pressure off wild populations, as well as providing employment. There is no better example of this than the butterfly ranching/farming programme in Papua New Guinea where some villagers earn more income by maintaining their forests for insect breeding than by converting them to coffee plantations (Orsak 1993).

What is the compromise?

Private collecting by amateurs is a very important part of science and the inventory of our natural world. Many biologists began their careers from a background of collecting, and private collections and the data associated with them are an important (sometimes the only) source of information on the past occurrences of many species of invertebrates. A major need is for private collectors to be educated and aided in their endeavours so that the information they gather is made available to appropriate authorities to assist management. This includes, besides responsible collecting, gathering a minimal data set that notes locality, date of collecting and habitat information, and lodgement of information or specimens in recognised public institutions (such as State museums).

Codes of practice

Voluntary 'collecting codes' stress the need for responsibility and avoidance of overcollecting. The Joint Committee for the Conservation of British Insects published a 'Code for Insect Collecting' (Joint Committee for the Conservation of British Insects 1971), which urges restraint in collecting rare species (only a pair be collected), preferably towards the end of the mating/breeding season.

The Entomological Society of Victoria has a short list of species in the 'Limited Voluntary Protection' category (Anonymous 1988). Members of the Society are requested that any one collector nets no more than two specimens within any one season, and that no larvae or pupae be collected at any time.

Legislation

Responsible invertebrate collecting should not be discouraged. Legislation will be required to protect species that are known to be threatened and thus warrant protection, but should not alienate people who can contribute substantially towards understanding the species, and is not an end in itself. Responsible collecting will result in getting important distributional information for conservation management through the adoption of some kind of Code of Practice rather than a legislative prohibition. Since the passing of the Flora and Fauna Guarantee Act in Victoria, over 20 species of threatened invertebrates have been listed as protected wildlife (Butcher *et al.* 1994). Only four of these species are butterflies, and most of the listed species are not in the 'desired collectable' category. One aspect of the Victorian experience is that much of the information used by the Scientific Advisory Committee to determine whether a species is actually threatened is based on information collected by amateurs (e.g. Crosby 1987, 1990).

While protective legislation is necessary to assist the recovery of threatened invertebrate species, there is the danger that blanket prohibitive legislation, with its legal and bureaucratic barriers to pursuing a hobby, will simply discourage useful gathering of information by non-specialists and encourage the hiding of information by less scrupulous collectors. Such blanket legislation usually involves the protection of taxa that are known not to be threatened (Yen and Butcher 1994).

Conclusion

Collecting has often been cited as a threatening process for invertebrates. There are some cases where collecting has caused serious decline in the populations of some species, but in many cases, those species were already at risk through habitat alteration. The nature of collecting is complex, and its effects will depend on factors that involve the biology of the target species, its abundance, and the timing of collecting. The paucity of information about most of the Australian invertebrate fauna requires the encouragement of responsible collecting by hobbyists, students, naturalists and professionals, as long as the information that they collect is lodged with the appropriate institutions and made available for incorporation into conservation management programmes.

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The Species: Elements of a Management Plan

T.R. New[1]

Introduction

Conserving species is commonly not simply a question of reserving habitat for them, although this may be critical because, without a place to live a species clearly cannot survive. However, to assure the sustainability of the species in a habitat, some form of management may be needed, and this must be based on sound knowledge of the species' requirements. This knowledge is difficult to obtain for many invertebrates, and this paper is a brief outline of the components of a management plan for these animals to indicate some of the problems involved in designing and executing practical conservation measures.

Problems in determining status

Species conservation, making a species the target for practical conservation activity, involves a complex and intricate series of operations which may need to be undertaken with very little practical knowledge of the subject. For many invertebrates, even the various components of status i.e. basic information on distribution, population dynamics, and population structure, may be fragmentary. Determining decline (decrease in numbers or range) and vulnerability (susceptibility of change) can also be difficult, because many invertebrates normally exist in very small populations, may be detectable easily for only short periods within each generation (such as during a butterfly's flight period), undergo intricate and highly specific interactions with other taxa, and may be susceptible to remarkably subtle anthropogenic changes to its environment (such as changes in exposure due to clearing of vegetation). In addition, most invertebrates targeted for conservation are rare and highly restricted in geographical range; many are known from single sites or colonies, and quantitative sampling or detailed investigation involving intrusions to the habitat may be ill-advised. Redressing these impediments is usually impossible in the short term and, at least, several seasons (often, years) of investigation may be needed to furnish even moderately reliable biological information. Nevertheless, accurate determination of a species 'status' is the standard against which the need for complex management or recovery plans must be assessed. It is important to (1) assemble and incorporate all available information whilst (2) appreciating that this may be inadequate and that it may be necessary to provide for approximation rather than rely on precise quantitative data. Thus, it is often impossible to obtain sound data on the population dynamics (including major factors causing mortality) for rare invertebrates, or to infer the precise causes of the (often) several-fold differences in numbers which can occur in successive generations.

In short, rare invertebrates are difficult and expensive to study, and the data resulting from substantial funding may still be poor. Chance environmental variations may have pervasive effects (New 1994). For example, a three-year survey for the lycaenid butterfly *Acrodipsas myrmecophila* at Mount Piper, Victoria, yielded evidence of only five individuals, all seen hilltopping. The sole known ant host of the caterpillars of this species was not located during an extensive survey of ants in the area. It was therefore not possible to define the critical habitat for *A. myrmecophila* from that survey, and thus any constructive management plan for its conservation will lack vital information. However, and more positively, the presence of the butterfly was confirmed in three consecutive flight seasons. Even though its existence may be tenuous, it is likely that maintaining the area in its pres-

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ent state will permit its continued survival. For rare invertebrates, 'presence/absence' data may have to be used in place of numerical data in conservation planning. Even confirming the presence of such scarce animals (or, conversely, detecting a decline or local absence) has a strong element of chance observation, especially for species known from one or few sites. Emphasis is thereby shifted from the species to the site(s) where it occurs so that the vulnerability of the site needs careful appraisal.

Management plans

The various stages in a species management plan (Fig. 1) show the general sequence of options usually available which stem from needs demonstrated by status evaluation. An invertebrate is regarded as threatened or vulnerable if a decline in its abundance and/or geographical range can be demonstrated. The geographical range may cover a large area or involve disappearances from particular sites. If local extinctions are not the consequence of a normal metapopulation structure (i.e. whereby a population exists over a greater area but occupies particular sites in a series of rolling colonisation-extinction cycles), the need for management to ensure survival at remaining sites may be urgent. Management must then include understanding and controlling threats, protecting the habitat (perhaps involving expensive land purchase, or legal reservation) and restoring critical resources (such as food plants or other specific needs) which are in short supply. Conserving the species may entail maintaining current levels of abundance by arresting a decline or more aggressive (and more costly) attempts to foster recovery, perhaps incorporating translocation or other ex situ measures (New and Yen 1994, Yen and New 1994). Lastly, it is important, even critical, to monitor the effects of management as fully as possible by assessing subsequent trends in numbers and distribution of the target species, and to refine management progressively in response to increased ecological knowledge.

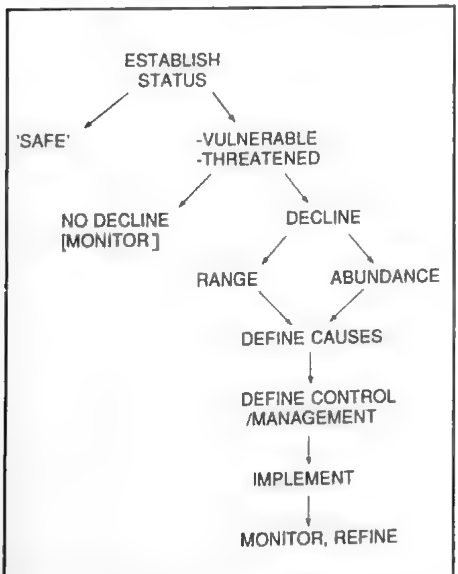

Fig. 1 Elements of a species management plan.

Discussion

The steps outlined here demonstrate clearly that single species conservation of invertebrates is not merely a question of 'locking up' a habitat or site, although this may be the only practical interim step to secure a critical area against conflicting demands and exploitation by people. In some instances, listing or designation of a species for conservation priority has led to studies resulting in the knowledge that the species is far more secure than had been supposed. The Damselfly *Hemiphlebia mirabilis* is an example in Victoria; it is now known from several sites in Victoria and Tasmania but at the time of listing under the Flora and Fauna Guarantee Act it was believed to be confined to Wilsons Promontory. Without the impetus provided by its initial listing, the requisite surveys which clarified its status would probably not have been conducted.

The massive ecological diversity of invertebrates ensures that extrapolation from knowledge of one species to another may not be realistic, but the above scheme and the increasing number of relevant case histories from various parts of the world suggest that it may be possible to derive comparative conservation protocols. At least for butterflies, sufficient cases have been studied to indicate the generalities of this although, as for most other invertebrate groups, many programmes have not progressed satisfactorily beyond status evaluation and consequently management needs remain uncertain.

Pollard and Yates (1993) summarised standard techniques for assessing butterfly numbers, and Arnold (1983) presented an initial pro-forma management scheme for lycaenid butterflies, for example. Ideally, protocols should (1) be sufficiently general for easy replication in space and time and (2) be sufficiently flexible to be applied with little change to different taxa and habitats, as well as (3) incorporate the need for future comparative use for repeated monitoring at the same site(s) or extrapolation to other localities for the same or related taxa (New 1994). They should also incorporate all possible facets of conservation activity, such as promoting public awareness, legal protection (if needed), habitat protection, threat abatement, consideration of captive breeding or translocation to augment low populations, and autecological studies of the target taxa, together with provision for continued monitoring. A comprehensive management plan for an invertebrate species cannot be undertaken lightly. It is likely to be a complex, long-term process involving original discovery and scientific investigation rather than confident application of established or well-tried recipes.

Perhaps the most complex management is that which involves taxa relying on early successional or transient habitats, having intricate associations with specific plants and other animals, and exhibiting a metapopulation structure. This is exemplified by many lycaenid butterflies (New 1993) whose caterpillars associate with specific ants in early successional vegetation. Their localised extinctions may sometimes be entirely natural as grassland is replaced naturally by other vegetation and so do not require a rapid 'crisis-management' response. If such invertebrates continue to be scheduled for conservation management it is important that adequate resources are allocated to ensure that the programme has at least reasonable chance of success.

Conclusions

The steps noted in Fig. 1 are simplistic, and it may be necessary to review continually the progress of management and to refine the needs and implementation as more information on the species' biology is obtained. Defining 'status', and reviewing changes in response to management, is a central need in any such long-term programme. It is rarely possible to design and execute an 'ideal' management plan for an invertebrate species, simply because of the complexity of invertebrate assemblages and the diversity of species which may be present in any particular habitat. Nevertheless, conservation action will usually involve the need for management, and the scheme outlined here indicates how this may be pursued constructively.

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Conservation of Victorian Butterflies

by Ross P. Field[1]

Undoubtedly the invertebrate group that has the widest general public appeal as a symbol of an unspoilt environment is the butterflies. This is largely because of their size, colour, diurnal appearance and, over the last 10 years, their high profile created by the worldwide proliferation of butterfly houses. They have become a banner for urban conservation, thus, it was appropriate to have the Eltham Copper Butterfly, *Paralucia pyrodiscus lucida* Crosby, as a test case for the conservation of invertebrates under the Victorian Flora and Fauna Guarantee Act (1988) (FFGA) (New 1991). Besides being readily identifiable elements of our fauna and thus suitable banner species for conservationists, butterflies may be good indicator species of the health of the habitat (New 1991). However, in adopting particular species it is important to understand their ecology. Naturally rare species will involve different issues from abundant species that are on the decline as will migratory species versus more sedentary ones (Sands 1990).

There are many butterflies that are uncommon in Victoria because they are either migratory or their natural distribution extends southwards into small pockets of far eastern Victoria. These are not considered in this paper from the point of view of conserving threatened species as they are more than likely naturally rare towards the extremity of their range. Table 1 indicates the uncommon species that were probably more widely distributed and abundant 100 years ago and today are only preserved in reserves or continue to face decline through habitat destruction.

The biology of most butterfly species that occur in Victoria has been well documented, or at least could be reasonably presumed from populations of the same species elsewhere. However, some lycaenid species are poorly understood because their life histories are closely associated with ants. In particular the biology of the probable myrmecophagous species *Acrodipsas myrmecophila, A. brisbanensis and Ogyris idmo halmaturia* are virtually unknown and all are threatened species and listed as endangered under the FFGA (CNR 1993). The larvae of these species are thought to develop in ant nests. For *A. myrmecophila,* the ant is from the *Papyrius nitidus* group, the species associated with *A. b. cyrilus* is unknown and that associated with *O. i. halmaturia* is a sugar ant, *Camponotus testiceipes* (Field 1992). Each of these butterflies occur in few locations and in the case of *O. i. halmaturia,* no specimens have been collected in Victoria since 1972, and these specimens, from Mildura, may belong to an undescribed species known from Kalgoorlie in Western Australia which has also recently been recorded from the Riverland area of South Australia. Conservation of this species, and the two *Acrodipsas* species, is thus made more difficult because it is the protection of specific ant species, and not unique vegetation that will govern the survival of the species. However, in the case of the *Acrodipsas* species they are generally known from specimens collected on hilltops which focus naturally rare species for mating. These species may be more common than realised because there are relatively few sites (conical wooded hills where the species fly at the tops of the trees) where they can be easily observed. The only extant population of *A. myrmecophila* and the major site for *A. b. cyrilus* is Mt Piper, near Broadford. This area was recently listed under the FFGA as a threatened community (Butterfly Community No. 1) and 140 ha of the Mt Piper reserve and adjoining areas has received National Estate nomination.

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Table 1. Uncommon Victorian Butterflies (non-migratory) and their conservation status.

Family and Species	Locations	Habitat	Larval food	Conservation Status
Hesperiidae				
Trapezites sciron eremicola Burns (sciron skipper)	Little Desert National Park; Big Desert wilderness	Hilltopping - sand dunes	*Lomandra glauca*	Protected in reserves- locally common (Dunn and Dunn 1991)
Hesperilla flavescens flavescens Waterhouse (yellowish skipper)	Widespread but local from Altona to south western Victoria	Swampy and saline areas supporting food plant	*Gahnia filum* (also *G. radula* and *G. trifida*)	Occurs in some reserves although a significant site at Altona is being degraded - locally common (Crosby 1990)
Hesperilla crypsargyra lesouefi Tindale (silvered skipper)	Grampians National Park, Burgoynes Gap near Licola, Valencia Creek. near Briagolong	Disturbed areas (road cutting on Mt William) above 300m where food plant grows.	*Gahnia microstachya*	Main colony protected in Grampians National Park - locally common (Common and Waterhouse 1981)
Antipodia chaostola chares (Waterhouse) (chaostola skipper)	Widespread from east Gippsland to the Grampians National Park	Dry heath areas with Gahnia regrowth	*Gahnia radula* (also *G. sieberana* and *G. microstachya*)	Protected in the Grampians National Park but less secure in the small colonies of eastern and central Victoria - rare (Atkins 1984)
Antipodia atralba atralba *(Tepper)* (black and white skipper)	North western Victoria - Big Desert, Hattah and near Rainbow	Mallee bushland supporting *Gahnia* populations	*Gahnia lanigera* (also *G. ancistrophylla*)	Protected in National Parks and reserves - restricted and rare (Douglas and Braby 1992)
Anisynta cynone grisea Waterhouse (cynone skipper)	Northern and western Victoria - Kerang to Dimboola	Occurs in wastelands in towns where rice millet grows	*Oryzopsis miliacea;* native food plant unknown	Subject to the effects of weed control in towns - locally common (Douglas and Braby 1992)
Nymphalidae				
Heteronympha banksii nevina Tindale (Banks' brown)	Grampians National Park	Wet sclerophyll forest gullies	*Poa* spp. and other soft grasses	Protected in the National Park - locally common (Common and Waterhouse 1981)
Heteronympha cordace wilsoni Burns (bright-eyed brown)	Grampians National Park to near Dartmoor	Boggy sedge areas supporting abundant host plants	*Carex appressa*	Protected in the National Park; drainage of swampy areas is a major threat - vulnerable (Dunn and Dunn 1991, CNR 1993)
Oreixenica kershawi kanunda Tindale (Kershaw's brown)	Portland and Nelson	Wet sclerophyll forest grasslands	Grasses which include *Poa* spp. and *Tetrarrhena juncea*	Restricted locations threatened by habitat destruction - locally abundant (Crosby 1989)
Oreixenica latialis theddora Couchman (alpine silver xenica)	Mount Buffalo National Park	Alpine meadows above 1200m	*Poa* spp.	Protected in National Park - locally abundant but vulnerable (Common and Waterhouse 1981, CNR 1993)
Tisiphone abeona antoni Tindale (sword grass brown)	South western Victoria - Grampians, Dartmoor and Portland	Swampy areas supporting large clumps of *Gahnia*	*Gahnia sieberana*	Protected in National Park; drainage of swampy areas is a major threat

Family and Species	Locations	Habitat	Larval food	Conservation Status
Lycaenidae				
Ogyris otanes C and R Felder (small brown azure)	Big Desert Wilderness area	Hilltops on sand dunes and often has flight paths close to the breeding areas	*Choretrum glomeratum* in association with the sugar ant *Camponotus testaceipes*	Discovered in the 1970's but may be widespread in the Wilderness area although only known from one extant and one extinct population - endangered (Crosby 1972, Quick 1974, CNR 1993)
Ogyris idmo halmaturia Tepper (large brown azure)	Kiata, Portland, Grampians, Mildura(?)	Usually mallee habitats but always associated with the ant *C. testaceipes*, often has flight paths away from ant areas	Life history is unknown but suspected to be predatory on *C. testaceipes*	Last recorded at Mildura in 1972 although this may be an undescribed species- endangered (Field 1992, CNR 1993)
Hypochrysops ignitus ignitus (Leach) (fiery jewel)	Little Desert National Park, Big Desert Wilderness area, Ocean Grove and near Melbourne	Variety of habitats, mainly close to the coast but inland to Red Bluff in the Big Desert; males hilltop	*Brachyloma daphnoides*, *Acacia pycnantha* and *A. decurrens* and with ants from the *Papyrius nitidus* group	Protected within the Little Desert National Park; and by the expansive area of the Dig Desert - very local and rare (Fisher 1978)
Acrodipsas brisbanensis cyrilus (Anderson and Spry) (large ant-blue)	Croajingalong National Park, You Yang Ranges, Mount Piper near Broadford and Warrandyte/Kangaroo Ground	Generally found hilltopping (mostly males)	Life history is unknown but larvae are suspected to be predatory on ants as are other species in the genus	Protected in National Parks and reserves and under the Victorian Flora and Fauna Act - endangered but may be more widespread (Dunn and Dunn 1991, CNR 1993)
Acrodipsas myrmecophila (Waterhouse and Lyell) (small ant-blue)	Known from Ocean Grove, where a reserve was created, and Mt Piper, near Broadford	Generally found hilltopping (mostly males) or close to stumps containing ant nests	Predatory on ant brood - *Papyrius nitidus* group	Protected under the Victorian Flora and Fauna Act; only current location is Mt Piper but may be more widespread - endangered (CNR 1993)
Candalides consimilis goodingi (Tindale) (consimilis blue)	Eastern Victoria to the Dandenong Ranges	Wet sclerophyll forest	Unknown in Victoria but could include *Clematis glycinoides* and *Hedera helix* (Ivy)	Probably well protected in National Parks and reserves - rare but more common in the east (Dunn 1990)
Candalides absimilis (Felder) (pencilled blue)	Mitchell River National Park	Rainforest areas	Unknown in Victoria but could include *Brachychiton populneus*	Protected in the National Park - abundant at times (Dunn 1990)
Paralucia pyrodiscus lucida Crosby (Eltham copper)	Widespread but fragmented colonies near Kiata, Castlemaine and Eltham	Dry open forest	*Bursaria spinosa*	Most populations are outside reserves but a land purchase in Eltham has resulted in a small reserve for the largest colony - vulnerable but locally common (Braby *et al.* 1992, CNR 1993)
Pseudalmenus chlorinda fisheri Tindale (Victorian hairstreak)	Grampians National Park	*Acacia* woodland	*Acacia melanoxylon*	Protected in National Park - very local and vulnerable CNR 1993)
Theclinesthes albocincta Waterhouse	North western Victoria - Pink Lakes	Distribution is unknown but dependent on *Adriana* which occurs on the coast and inland	*Adriana hookeri*	Protected in National Park (CNR 1993)R

A number of butterfly populations in the south-west of the state, albeit local forms or recognised subspecies, particularly from the families Hesperiidae and Nymphalidae, are threatened where land clearing and draining followed by grazing has reduced suitable habitats. Many of these populations now only have strongholds in the National Parks (Table 1) where bushfires and land degradation through weed invasions and rabbit grazing constitute the major threats to their survival.

Throughout the state, habitat destruction has contributed to many butterfly species being reduced in abundance. It is important that ecological studies are undertaken on remnant populations of many of our uncommon species and that their habitats are conserved so that preservation of genetic diversity of the species can occur. This will also give local communities 'banner species' that provide platforms to address broader conservation issues.

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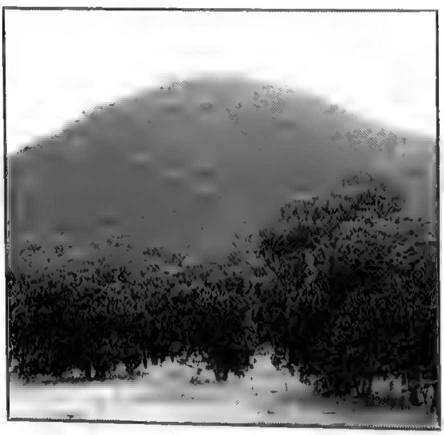
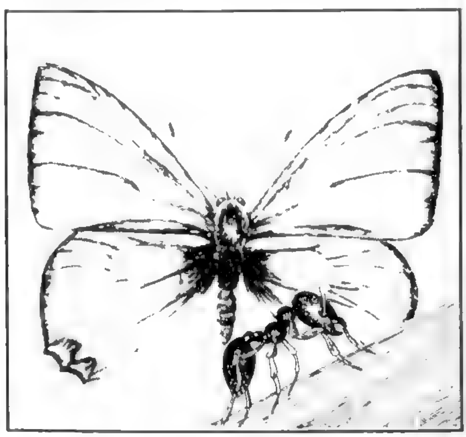


Mt Piper from Jeffreys Lane.



The Large Ant-blue Butterfly, *Acrodipsas brisbanensis cyrilus*, and its attendant ant, *Papyrius* sp. aff. *nitidus*.

Conservation Strategy for a Threatened 'Butterfly Community'

Ann Jelinek[1]

Introduction

The conservation strategy for a threatened ecological community, listed as Butterfly Community No. 1 on Schedule 2 of the Victorian Flora and Fauna Guarantee Act 1988, integrates legislative responsibilities with surveys, research, management, public awareness and involvement, and local government statutory processes.

Butterfly Community No. 1 is characterised by an unusually high diversity of ants and butterflies (at least 40 species), including threatened, locally rare and migratory butterflies. A detailed description of the butterfly assemblage and associated flora and fauna, ecology of the Ant-blue butterflies, habitat, threats, research and management is provided in Jelinek *et al.* (1994).

The only known occurrence of this butterfly assemblage is on and surrounding Mt Piper in central Victoria. Mt Piper (37°12'S, 145°0'E) is a steep, solitary mountain rising from 230 m to 440 m above an undulating plain between the Tallarook and Mount William ranges near Broadford. Mt Piper is a quartz plug or epithermal deposit of quartz and other minerals deposited by hot solutions.

Major threats to the butterflies include removal of trees on Mt Piper summit which are used by many moths and butterflies for 'hilltopping' or mate location; changes to vegetation composition and successional stages, especially acacias and mistletoes which are important food sources for caterpillars; and loss of dead standing and fallen timber used by the Coconut Ant, *Papyrius nitidus* which associates with the Ant-blue butterflies, *Acrodipsas myrmecophila* and possibly *A. brisbanensis*.

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Conservation Strategy

Key elements of the conservation strategy include an Action Statement and Research Plan, surveys and research, habitat management, public awareness and involvement, and statutory planning.

Action Statement and Research Plan

An Action Statement and a Research Plan for Butterfly Community No. 1 (Jelinek 1991, 1992) document the distribution and biology of significant species making up the butterfly assemblage and known threats to the community. They highlight high priority research and management actions needed to achieve conservation of the community in accordance with the Flora and Fauna Guarantee Act 1988 and Endangered Species Protection Act 1992 respectively.

Issues raised in these plans have important implications for the long term conservation of Butterfly Community No. 1, in particular: use and management of Mt Piper trigonometric station and communication facilities; rehabilitation works; visitor use; public involvement in butterfly habitat conservation; vegetation management and clearing on private land adjoining Mt Piper; fire wood collection; fire management; land use zoning and the potential environmental impacts of mineral exploration and mining activities.

Surveys and research

Field work has focused on monitoring populations of the target butterflies, *Acrodipsas myrmecophila*, *A. brisbanensis cyrilus* and *Ogyris genoveva genoveva*, at known and potential hilltopping sites, intensive ant surveys, assessment of historic and currently known habitats of the Coconut Ant, *Papyrius nitidus* and documentation of flora, fauna and other important habitat characteristics on and around Mt Piper. Monitoring of the Golden Sun Moth, *Syn-*

emon plana, in native grassland at Mt Piper has been carried out over the past two years since its discovery at Mt Piper (Britton and New 1993).

During the past three years there has been recorded at Mt Piper an additional 20 butterfly species, the 'endangered' Golden Sun Moth and over 130 morpho-species of ants. Also, similar butterfly assemblages have been located elsewhere in central Victoria. Surveys of other fauna and detailed habitat assessment and vegetation mapping has contributed to a better understanding of the ecological community, particularly the fluctuations in invertebrate diversity, depending on seasonal conditions (Beardsell 1994; Britton and New 1992, 1993; S. Hinkley *pers. comm.* 1993; Jelinek 1994; New *et al.* 1994; D. Britton *pers. comm.* 1994).

Importantly, the results of the surveys and research provide a good basis for:

- developing effective habitat management guidelines;
- determining the *critical habitat* of Butterfly Community No. 1;
- identifying opportunities for public involvement in butterfly habitat management;
- preparing a nomination of the core area of the *critical habitat* for listing on the Register of the National Estate, and
- preparing and implementing a Recovery Plan in accordance with the Commonwealth's Endangered Species Protection Act 1992.

Habitat management

Habitat management at Mt Piper includes removal of feral goats, hand removal of thistles, restriction of vehicle access to a formalised parking area, removal of many disused radio communications structures on and around the summit, erosion control and rehabilitation of the steep vehicle and walking track leading to the summit, construction of a scenic walking track and fencing of an adjoining grazing property.

Broadford Shire Council recently signposted roadside vegetation in the area to prevent clearing, fire wood collection and unplanned fire. Agreement has also been reached to replace traditional line of site clearing requirements around the trig. station with satellite survey techniques which need minimal site disturbance and maintenance. Gazettal of regulations under the Conservation, Forests and Lands Act 1976 specific to Mt Piper Education Reserve ensure that activities within the Reserve reflect the important scientific, cultural and educational values of the area.

The proposed Amendment L8 to the Broadford Shire Planning Scheme will provide Conservation Zoning of Mt Piper and its environs through vegetation clearance controls over private and public land. It is based on guidelines specifically developed to manage native and semi-native vegetation on and surrounding Mt Piper for invertebrate conservation. These guidelines are actively promoted and are, wherever possible, complemented by joint on-site inspections with landholders.

Public awareness and involvement

Increased public awareness of the environmental significance of Mt Piper is achieved primarily through improved management, information and involvement. An on-site information display, brochure and media items help to convey important messages about the area's ecology. Broadford Secondary College students use Mt Piper Education Reserve for environmental education; others visit Mt Piper to enjoy the superb views from the summit and to see the diversity of flora and fauna, especially butterflies, or to explore the area. Ideas and feedback from visitors are obtained from a Visitor's Book included with the information display.

The most suitable breeding habitats for many of the butterflies and the Golden Sun Moth occur on private land adjoining Mt Piper Education Reserve. Public awareness and involvement are therefore an essential part of the conservation strategy. In particular, the long term success of the conservation strategy depends on the cooperation of landholders with habitat management activities, most importantly, maintaining vegetation in a range of successional stages, leaving areas with dead standing and fallen timber and avoiding overgrazing of native grasslands. Incentives for landholders to protect and enhance remnant native vegetation are available through *Landcare, Save the Bush, Botanic Guardians* and *Land for Wildlife* programs which, in some cases, include financial assistance.

Broadford Shire Council and Broadford Environmental Action Movement (BEAM) are facilitating the proposed amendment to the Local Planning Scheme for conservation zoning over all properties within the identified *critical habitat* of *Butterfly Community No. 1* (Jelinek 1994). BEAM and other groups like Project Mansfield and Mansfield Secondary College, maintain public awareness about the importance of native vegetation and hilltops for butterfly conservation through regular publicity and by encouraging involvement of land management and school groups in conservation activities. Strong community concern has been rekindled on several occasions with applications for mineral exploration in the Mt Piper area.

Critical Habitat

In accordance with the FFG Act, 'critical habitat' is defined as *the whole or any part or parts of the habitat of the community that is critical to the survival of that community.*

Mt Piper forms the core area of the identified critical habitat, with the summit being important for hill-topping species. The *critical habitat* also includes known and potentially important butterfly and moth breeding sites on the lower slopes of Mt Piper, outside Mt Piper Education Reserve and in roadside vegetation where colonies of the attendant ant, *Papyrius nitidus* have previously been recorded. It covers approximately 150 hectares, with approximately 15 km of roadside vegetation. The proposed Amendment L8 to the Broadford Shire Planning Scheme, National Estate interim listing and critical habitat determination each cover the same core area centred on Mt Piper.

Discussion

Within three years, high priority research and management activities identified in the Action Statement and Research Plan have been completed or are in progress. The detailed study of ants and habitat characteristics provides a valuable basis for defining *critical habitat* characteristics and identifying potential breeding sites of the Ant-blue and Genoveva Azure Butterflies.

Key environmental features identified include naturally vegetated mountain landscapes, all successional stages of eucalypts and acacias, decaying ground timber, stumps and leaf litter, mistletoes and native grasslands. Comparative surveys at other mountain sites further highlight the significance of naturally vegetated, isolated, mountain peaks for hilltopping butterflies and moths.

Long term protection of the critical habitat of the butterfly assemblage at Mt Piper is provided by statutory planning and legislative processes. The core area of the identified critical habitat, including public and private land, is also on the interim list of the Register of the National Estate based on its significance for invertebrates, particularly butterflies.

Increased public awareness, improved hilltop management, maintenance of vegetation in a range of successional stages and a study of ant species distributions and ecology within the habitat are priorities for future management and conservation of Butterfly Community No. 1 Better understanding of the relationships between the *Acrodipsas* butterflies and ants will further assist with identifying habitat requirements of these threatened species throughout their respective distributions. On-going public involvement with the management of hilltop, native grassland and successional habitats are also contributing to achieving broader conservation goals.

Acknowledgments

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Marine Invertebrate Conservation at San Remo

T. O'Hara[1]

Introduction

The extensive reef and seagrass flats off San Remo support a distinctive assemblage of marine invertebrates. The rarity and vulnerability of these invertebrates has been recognised by the listing of the 'San Remo Marine Community' on schedule 2 of Victoria's *Flora and Fauna Guarantee Act* 1988 (Reed 1992). This listing was initiated in response to a proposal to develop a large marina on the site. Permission to develop the marina was subsequently refused under the *Planning and Environment Act* in 1991. However, the location of this site, adjacent to the township of San Remo and near to the very popular coastal tourist facilities on Phillip Island, presents a challenging long term conservation objective.

Site Description

The San Remo site is at the south-eastern corner of Western Port Bay, north-east of the Phillip Island bridge. It extends along the coast for 1.75 km north-east from the bridge, and seawards 300-500 m, from the shore to the deep channel that runs between San Remo and Phillip Island (Fig. 1).

The site has a combination of physical attributes that have not been found elsewhere in Victoria, and possibly southern

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Australia. The site has a northerly orientation. It is generally subject to low wave energy although occasionally receiving storm waves from the north. It is adjacent to a fast flowing channel and has excellent tidal flushing, contributing to the nutrient availability. The rock is a weathered vesicular basalt. It is very unusual to find such rock in the intertidal zone as it is quickly eroded by wave action. The sedimentation regime is poorly understood, although nearby cliffs are actively eroding.

A detailed model of the waves and tides at San Remo has never been developed. A large scale model of Western Port Bay, developed by the Victorian Institute of Marine Sciences (VIMS), indicates that there is a net current inflow through the middle of the channel, that travels northwards, and then circulates eastward and southward around Reef Island. The smaller net current outflow is likely to travel along the edges of the channel (Dr K. Black, VIMS *pers comm*).

The reef flats support a complex mosaic of substrata including: sand, mud, coarse shingle, seagrass, algae and rock. The exposed rocky areas are more extensive at the western end, including an important section near the No. 7 beacon. The soft vesicular basalt provides many microhabitats for invertebrates. Species rich shingle beds lie parallel to the channel in the middle of the site. Mud and seagrass beds predominate to the east, extending around the coast to Reef Island. Near the Bass River Estuary, they are backed by mangroves.

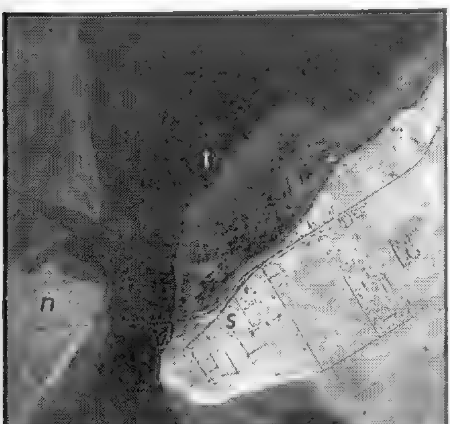

Fig. 1. Aerial photo of the San Remo area, showing the location and extent of the reef and seagrass flats. Symbols are as follows: n - Newhaven township, Phillip Island, s - San Remo township, and t - San Remo tidal flats. *Crown Copyright Reserved.*

Examination of recent aerial photographs has revealed that these beds are part of one of the few large expanses of seagrass left in Western Port Bay. The two dominant seagrasses are *Heterozostera tasmanica* and *Zostera muelleri*. Together they cover over 55 % of the area from the San Remo bridge to the No. 7 beacon. This cover increases to over 90 % at the east of the site (Handreck 1994). The presence of healthy seagrass is probably due to the lack of sediment pollution in the area. The inflow to the area is largely from Bass Strait, via the channel, rather than from the north of the Bay where the major sources of sediment are located (Dr K. Black, VIMS *pers comm*).

Marine Invertebrates

The marine invertebrates have been extensively surveyed by the Marine Research Group of Victoria (MRG) since 1981. One member, David Howlett, has visited San Remo in excess of 170 times (Burn 1990). The MRG has visited the site eleven times. The east of the site was surveyed four times as part of a year long study for the Department of Conservation and Natural Resources (Handreck 1994).

The surveys have found that the diversity of substrata at the site supports a correspondingly rich assemblage of marine invertebrates. Over 630 species have been recorded (Handreck 1994). This is almost certainly an underestimate of the total species present, as several groups of animals from San Remo have not been fully identified. These include sponges, cnidarians, worms and small crustaceans (isopods and amphipods).

The MRG has recorded the occurrence of 282 conspicuous marine invertebrates at intertidal and shallow subtidal locations along the Victorian coast (Handreck and O'Hara 1994). Of the 74 locations surveyed, only the basalt rock platforms at Shoreham and Flinders have a greater recorded percentage of the 282 species than San Remo.

The most distinctive components of the fauna are the spectacular range of opisthobranch molluscs and the very rich intertidal fauna of crabs and bryozoans. Opisthobranchs, misrepresented by their common name, seaslugs, are actually extraordinarily beautiful and graceful animals. One hundred and twenty five species have been recorded from the site (Handreck 1994). That is 25% of the known southern Australian species and over 6% of the world's species. Many are undescribed species (Burn 1990). Eleven species have only been recorded, or were recorded first, from the San Remo locality. Two species, *Platydoris galbana and Rhodope* sp, are listed independently under the *Fauna and Flora Guarantee Act.* Some opisthobranchs only appear seasonally.

Sixty-eight species of bryozoans (lace corals) and 40 species of crabs have been recorded from the San Remo reef flats and channel banks. This is many more than is usually present at shallow water locations.

Some of the San Remo species are usually found at deeper subtidal localities. This includes some of the bryozoans; the ctenophoran *Ctenoplana willeyi;* the gastropods *Muricopsis umbilicatus,* and *Favartia brazieri;* the bivalves *Anadara trapezia, Atrina tasmanica, Myllita tasmanica, Timoclea cardioides* and *Venericardia bimaculata;* and the crabs *Huenia australis, H. halei* and *Macropipus corrugatus.* The unusual soft basalt rock is also home to uncommon boring species. These include the bivalve *Barnea obturamentum* and the hermit crab *Cancellus typus.* Other very rare species include: the bryozoan *Alcyonidium sp;* the chiton *Acanthochitona wilsoni;* the opisthobranchs *'Retusa' sculpta, Elysia* sp. nov. and *Diaphorodoris* sp. nov.; the small red gastropod *Macrozafra cominellaeformis;* and a sylobrid flatworm. Some of these species are known from only a handful of specimens (Burn 1990; Handreck 1994).

Threats

The two reasons that the San Remo Marine Community was listed under Victoria's *Fauna and Flora Guarantee* (FFG) Act are that 1) it is significantly prone to future threats which are likely to result in its extinction, and 2) it is very rare in terms of total area it covers, has a restricted distribution, and has been recorded from a limited number of localities (Reed 1992). The most obvious threat is from marine and coastal developments, such as a marina. These developments potentially remove suitable habitat, alter currents, and change the sedimentation processes at the site. The San Remo marina proposals have situated the main entrance channel through the most species-rich section of the reef near the No. 7 beacon.

The sedimentation processes at San Remo are poorly understood. In similar locations, adjacent to a fast flowing channel, small alterations in coastal morphology have had a large effect on current regime (Dr. K. Black, VIMS *pers comm*). If the net sediment flow is west to east, an area east of a development could be exposed down to bedrock, removing the seagrass and reducing the diversity of habitats available to the marine invertebrates.

Other threats include: pollution, including sediment pollution from terrestrial development sites, and damage from boating, dredging and trampling (Reed 1992).

Conservation

The distinctive nature of the location and the assemblage of marine invertebrates at San Remo, the presence of so many new, uncommon and rare species, and their vulnerability from known threats, present a compelling case for conservation. Few southern Australian marine sites have such well known conservation values.

The listing of the San Remo marine

community and the two opisthobranchs on the FFG Act is a landmark in the progress of marine invertebrate conservation in Victoria. The FFG Act was designed to ensure the long term survival of Victoria's biodiversity. Action statements prepared for listed communities or species can specify management restrictions. The Action statement for San Remo requires the Victorian Department of Conservation and Natural Resources to prevent works or activities that will threaten the destruction of this marine community (Reed 1992).

There have been several scientific criticisms of the listings. The first questions whether the San Remo biota really form a 'community' in an ecological sense. Modern marine biologists hesitate to use the term 'community', preferring more restrictive terms such as 'faunal assemblage' until inter-relationships can be established. Regardless of the terminology, however, the underlying conservation objectives are the same. The San Remo site has a unique set of physical characteristics that supports a very distinctive faunal assemblage, including many rare species.

The second criticism questions whether any marine species can be restricted to one site, given the continuous nature of the marine environment. Indeed, one of the listed San Remo opisthobranchs, *Platydoris galbana,* has been recently recorded off the Ninety Mile Beach (R. Burn *pers. comm.*). Nevertheless this presumption does not hold true for all species. Current research has revealed that some conspicuous southern Australian marine invertebrates are restricted to very small sections of the coast (O'Hara *unpubl.*). Other species are vulnerable for different reasons, including their specific habitat requirements or their naturally low abundance (Handreck and O'Hara 1994). San Remo remains critical habitat for a number of species.

The San Remo FFG listings have not been viewed favourably by some sections of the community. Proponents of the marina have of course voiced their opposition. Chisholm and Moran (1993) have used the listing as a case study of the adverse economic implications of the FFG Act. They imply that the economic benefits of developments such as a San Remo marina outweigh the conservation importance of a few marine invertebrates, and that a cash provision for another 'higher priority' conservation project would be an adequate compromise. The unjustified subjectivity of this argument is lamentable. Moreover, such a narrow view of biodiversity undervalues the importance of sites like San Remo in supporting ecological processes.

In contrast, the author's view is that the case study indicates the need for statewide coastal planning. The selection of San Remo as a site for a new marina has had more to do with local politics and council boundaries than objectively balancing the competing requirements of development and the environment.

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Vulnerable Ecosystems: Victoria's Alpine Regions

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Introduction

Victoria's alpine regions exemplify the problems of conserving invertebrates in natural ecosystems. They comprise a small but unique region of the State which supports a variety of endemic invertebrate life, together with other biota largely or wholly restricted to the areas above about 1250m a.s.l., mainly near or above the treeline. Together with New South Wales and Tasmania, alpine regions comprise an easily definable but highly restricted habitat and the problems faced by its invertebrates illustrate the difficulties of regional - or habitat-based conservation for an area subjected to a great variety of human and natural pressures.

Alpine areas are characterised by extreme climates, but only a few hundred km^2 are covered by snow for more than three months a year. They encompass a variety of freshwater habitats (including lakes, reservoirs, bogs and streams: Campbell *et al.* 1986), and terrestrial grasslands, heathlands, herbfields and shrublands with numerous plants restricted to the alps.

The history of European intrusion into the region involves traditional use of highland pastures for stock grazing in summer and winter sports activities, especially in areas most accessible from population centres, in winter. Much recent discussion over alpine conservation has verged on confrontation between conservationists, on one hand, and those who wish to accelerate development of winter sports facilities on the other, and a number of notable alpine invertebrates listed under the Flora and Fauna Guarantee Act have become embroiled in such arguments in areas controlled by the Alpine Resorts Commission. The Alpine National Park areas comprise a high proportion of the region, but are subject to grazing leases and extensive invasions by weeds and other exotic species. As in other parts of the world, alpine areas are sensitive and vulnerable to human intrusions.

As well as easily detectable anthropogenic changes, the more widespread threat of global warming during the next few decades poses the likelihood of substantial decline in present alpine area with loss of habitats critical for terrestrial taxa, in particular (Galloway 1988). Practical conservation for invertebrates must therefore incorporate minimising the effects of increased human intrusion and settlement (including roadworks, housing developments, aspects of water supply and waste disposal, increased visitor numbers and increased intensity of use) and endeavouring to safeguard sufficient natural habitat to assure the longterm survival of representative typical biota. Habitat restoration is needed in places, involving control of exotic plant weeds (Mallen 1986) which are already affecting the integrity of natural alpine communities.

Alpine invertebrates in Victoria

Many alpine invertebrates are highly localised, and much debate surrounds the status of some of these which appear to be limited to particular mountains or sites and are thereby vulnerable, and may become directly threatened by particular development proposals. A simple strategy of protecting a particular subregion of the alps (such as designation of 'wilderness areas') is therefore not wholly satisfactory, and there is need for more widespread, mosaic, conservation efforts. There are thus two major, complementary, foci for invertebrate conservation in the alps: (1) rare or highly localised taxa under perceived threat now or in the near future, and which may need specific mea-

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sures to conserve them and (2) endemic faunas characteristic of, and restricted to, the alpine region which are not currently rare or threatened but which need the current suite of resources to be maintained if they are to remain sustainable.

The former include several freshwater taxa, such as stoneflies (Plecoptera) and planarian worms; the latter include taxa restricted to one alpine area (the satyrine butterfly *Oreixenica latialis theddora* is restricted to the Mt Buffalo plateau, where it is widespread) and others found more extensively over the higher altitudes (some geometrid moths: McQuillan 1986). Indeed, larentiine Geometridae, especially Xanthorhini, are particularly characteristic of uplands in southern Australia and New Zealand, with some species more narrowly endemic (McQuillan 1986). Whereas the alpine Lepidoptera have been defined reasonably well, this is not the case for some other terrestrial invertebrate groups, except in very general terms. Likewise, alpine elements in some aquatic insect (especially Plecoptera and Ephemeroptera) and crustacean orders are well defined (Campbell *et al.* 1986), but this is not the case in some others.

In both terrestrial and aquatic habitats, particular restricted species can be predominant (and, probably, functionally important) components of the fauna: the mayfly *Ameletoides lacusalpinae* occurs only near Mt Kosciusko and comprised 54% of the animals collected from Bogong Creek (Campbell and Graser, in Campbell *et al.*, 1986). By contrast, others are decidedly rare. Extensive searches for the Mt Donna Buang Stonefly *Riekoperla darlingtoni*, suggested that it is indeed restricted to a very small area near the top of that mountain (Neumann and Morey 1984); the Mt Stirling Stonefly, *Thaumatoperla flaveola*, occurs only on Mt Buller and nearby Mt Stirling (Pettigrove 1991).

Discussion

However, the heated conflicts engendered by attempting to secure habitats for such species in the face of demands for commercial development are difficult to defuse, and even undertaking objective surveys is difficult and sometimes eroded by political innuendo. A common sentiment is that, because of the remoteness and inaccessibility of much of the alpine region, the species involved may well occur elsewhere, so that assessment of conservation need based solely on current knowledge may be exaggerated. However, there is little doubt that some aquatic insects and others are genuinely highly restricted in distribution, and that more comprehensive study of the terrestrial fauna will reveal similar examples of narrowly endemic taxa. Baseline data on terrestrial invertebrate assemblages, in particular, is an urgent need for conservation assessment in Victoria's alps.

Wise management of the area is likely to involve increasing degrees of regulation to control deliberate human intrusion, and more active programmes to control exotic animals and plants. Much of this effort is directed toward maintaining the *status quo* and restoring perceptibly degraded sites.

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Threatened Ecosystems: Agricultural Environments.

Paul A. Horne[1]

This paper discusses the problems with, and potential for, conservation of native invertebrates in agricultural ecosystems. A few examples of how agriculture has affected invertebrates, in both positive and negative ways, are given. The large percentage of Victorian land used for different types of agriculture means that effects from agricultural practices are important to very many invertebrate species in different districts of the State.

Compared to most other ecosystems, agricultural environments are generally less diverse in terms of species richness. The main aim of most agricultural systems is to produce a single species (the crop or grazing animal) and monocultures are standard. For example, a vegetable grower may aim to produce one species of plant (the crop) per paddock and actively remove all competitors, both plant and animal (pests, diseases, and weeds). Despite this, surprisingly large communities of insects and other invertebrates do exist in agricultural ecosystems. For example, in Queensland, Cantrell *et al.* (1983) recorded over 160 species of beneficial Diptera and Hymenoptera plus other species of beneficial insects in potato crops.

Agricultural ecosystems are not generally constant or stable. Intensive horticulture or broad-acre cropping often involves removing all living plants from a paddock, either with cultivation or herbicides, then planting a crop which will be present for some months, and finally harvesting the crop and possibly destroying crop residues (e.g. by ploughing or burning). The habitat available for insects to utilise is, therefore, fairly transient. Insects need to be able to locate the crop and complete at least the part of their life-cycle dependent upon the crop before the plants are removed. Many insects are able to do this, but the most obvious are pest species.

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Other cultural practices such as irrigation change the habitat for invertebrates. For example, soil irrigated over summer will have a very different moisture gradient to that in natural, non-irrigated land. This may result in increased survival of some species, or alter the movement of species (e.g. larval Tenebrionidae) that have a vertical migration in soil based on moisture gradients (Robertson and Simpson 1988).

Another factor that affects invertebrates in agricultural ecosystems is that the species of plants being grown may often be varied. This may be as part of a regular rotation of crops, or the result of changing economic values resulting in new crops being planted. For example, the same piece of land in Victoria may be successively used for pasture, peas, potatoes and cereals or left fallow. Obviously such changes in the habitat will influence which invertebrates inhabit the area.

Not all agricultural land undergoes such dramatic change. Orchards, vineyards and some pasture may remain intact for very many years, thus providing a long-term habitat. These habitats are still essentially aimed at producing one species but they have a more stable and physically complex structure.

Apart from habitat change, the most obvious threat to the maintenance of invertebrate biodiversity in agricultural ecosystems is the use of pesticides, particularly insecticides, nematicides and miticides. Even herbicides will have an effect on invertebrate populations as they reduce the number of plant species present in an area and possibly for more than the life of the crop on which they were applied. For various reasons, there is a general movement away from total reliance on such pesticides but they still form a major part of crop protection measures in Victoria and Australia generally.

The crops and animals produced in Victorian agriculture are, in the main, introduced species. This limits the number of native invertebrate species that can utilise such habitats but generalist feeders may be more successful. There are also examples of native species being able to take advantage of the change in plant species composition. The native black-headed pasture cockchafer *Aphodius tasmaniae* is a beetle that is particularly favoured by the maintenance of clovers and pasture grasses in grazing land in southern Victoria and South Australia (Birks and Allen 1969). Other examples of native invertebrates favoured by pasture production include many caterpillars such as cutworms (Noctuidae), pasture tunnel moth (*Philobota productella:* Oecophoridae), *Oxycanus* and *Oncopera* (Hepialidae).

When insect pests become established in a crop or pasture, there is an almost unlimited supply of food. Insecticides are then often applied and non-target species can be affected more than the target pest (Jepson 1989). Little is known of the effects of particular insecticides on native invertebrates. Few data are available even for the effects on beneficial species in agriculture. In general, beneficial insects such as parasitoid wasps tend to be more susceptible than pest species to insecticides (Jepson 1989).

Broad-spectrum insecticides are still used regularly in Victorian agriculture and it can be assumed that they are limiting the number of species able to use agricultural habitats. However, the insecticides currently used are not as persistent as other chemicals (such as the organochlorines which are no longer registered for use) and so their effective (killing) time is less. That is, when there are only one or two insecticide applications the invertebrates present may be killed, but not those arriving a few days later. The effect on non-target species will depend, amongst other factors, on the timing of pesticide use, its persistence, the movement of invertebrates and the micro-environment of the invertebrates.

Rotation of crops, different grazing intensities, different degrees of clearing and different farming enterprises within any given district mean that the agricultural environment is a mosaic of different habitats at any particular time. Amongst the land used for farming are areas of remnant vegetation, of varying degrees of quality. These may be extensive or only the vegetation along the margins of watercourses and along roadsides. Mobile native species (such as the common noctuid pest *Helicoverpa (Heliothis)* sp.) will perhaps be more able to make use of agricultural habitats than those with long life-cycles and of limited vagility. We currently have extremely little information on the requirements of most native invertebrates (Hill and Michaelis 1988) and this limits our ability to effectively manage and conserve native invertebrate populations.

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Is There Life Beyond Butterfly Houses?

Alan L. Yen[1]

Introduction

Imagine walking through a humid rainforest when a brightly coloured butterfly gently alights on you. This scene is repeated thousands of times a day around the world, commonly in countries with a temperate climate! You are in one of the many butterfly houses now operating around the world - basically a walk through glasshouse with free-flying tropical butterflies, tropical plants and a suitable climate to maintain them.

The number of butterfly houses is surprisingly large, and more are being built every year, a phenomenon described by Pyle (1991) as a housing boom for butterflies. There are approximately 40 butterfly houses in the United Kingdom (Collins 1987), at least six (and probably double or triple that number) in the United States (Pyle 1991), and over 250 in the world (Bronaugh 1993). There are several in Australia, the best known being that at the Melbourne Zoo (Crosby 1986).

The yuk factor

Most people can identify with birds, mammals, reptiles and amphibians, and hence the popularity of zoological parks. There is less popular affinity with fish, and even less with invertebrates. Invertebrates are often not considered as animals and it is common to see or hear the phrase 'animals and insects'.

Ignorance of animal classification is only a minor problem for invertebrates. The major problem is the extreme and disproportionate level of loathing fear they can evoke in people - the 'yuk' factor. Some of the yuk factor can be rationally explained: spread of diseases by invertebrates, loss of agricultural production due to pest outbreaks, and venomous invertebrates species. This fear is widespread (Kellert 1993), although the truth is that the number of invertebrate species involved in activities harmful to people is very small, and the vast majority of species are components of the numerous food webs that form the basis of our life support systems.

The conservation value of butterfly houses

In contrast, most people like butterflies: attractive animals that are not dangerous to humans. Consequently, butterfly houses have been built to initiate the public into the world of invertebrates in a gentle manner. The major aim seems to be to create an awareness and appreciation of butterflies.

Most butterfly species displayed in American and European butterfly houses originate in Africa, Asia, or South America. Often, they are ranched or farmed in the countries of origin and exported to butterfly houses as pupae, hence providing a source of revenue for the economies of these nations.

Ironically, the butterfly trade (both in live specimens for butterfly houses and in dead specimens for collectors) may be of positive benefit in habitat conservation. In butterfly rich regions such as Papua New Guinea and South America, indigenous peoples derive higher incomes by preserving tropical forests for the butterfly trade rather than clearing them for crops (Bronaugh 1993; Orsak 1993).

The shortcomings of butterfly houses

Undoubtedly the value of butterfly houses exceeds their shortcomings, but the latter need to be addressed because of ramifications for lesser known invertebrates. Nearly all butterfly houses display large and colourful tropical species. While this is aesthetically pleasing and a good messenger for conserving tropical habitats, they are not directly relevant to the habitats where many butterfly houses are located: generally in affluent nations with temperate climates. Hence there is little reference to the conservation of local species in their own environments.

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The emphasis on one group of insects that represents only a limited range of trophic roles neglects the vast majority of species that form the basis of our biological diversity. There is danger that a new class of charismatic invertebrates will be established. Already there is the differentiation between the birds and other animals, and it is important that a 'butterflies and insects' syndrome does not develop. It is important that butterfly houses emphasise the message that butterflies are 'flagship' taxa for all the lesser known (and less attractive) invertebrate groups.

The non-butterfly live invertebrates display

Until the recent increase in butterfly houses around the world, there have been very few attempts to display other live invertebrates (with the exception of marine invertebrates in aquaria). The longest continuous such display is the Regents Park Zoo Insect House, which was established over 75 years ago. Today, several insect zoos/invertebrate houses concentrate on invertebrates other than butterflies. These include, as examples, the Smithsonian Natural History Insect Zoo, the Smithsonian Zoological Park Invertebrate House, and the Cincinnati Zoo Insectarium. However, most displays of invertebrates other than butterflies are set up merely as a minor addition to a butterfly house.

In Australia, an attempt was made to set up a live insect display as early as 1930 at the Burnley School of Agriculture (Anonymous 1930). Butterfly houses have been in operation in Australia for over a decade. Displays were set up in Queensland (such as those at Kuranda and Mount Glorious), but public attention was probably focused on the phenomenon with the opening of the Melbourne Zoo butterfly house (Crosby 1986). In Victoria, a small seasonal butterfly house recently opened near Castlemaine. Several other butterfly houses are found around Australia, and the one at the Brisbane Southbank location has several species of live invertebrates in addition to butterflies. Local social insects are displayed at the Northern Territory Wildlife Park near Darwin, and Macquarie University recently put up a display of an ant colony (Anonymous 1994).

There is still no venue in Australia that displays a broad range of live invertebrates in a non butterfly house setting. It is important to do so because butterflies are only a small, although obvious, component of the invertebrate world and are not representative of many major ecological roles. Efforts are now required to display a broader range of invertebrates, capitalising on the good image that butterflies already have, as an important avenue in conservation education.

The display of invertebrates other than butterflies has a major advantage in that they do not require large flight areas. Small-bodied invertebrates can be displayed in a relatively small space, and it is possible to display a broad range of representative invertebrate biodiversity in a small space.

More importantly, with live invertebrates, it is possible to exhibit functions: displays can be mounted where people can watch invertebrates go about their normal lives (such as feeding on plants, predator-prey relationships, decomposition, etc.) in more complex systems.

The need for using live invertebrates for display may be questioned. Dead specimens, models and photographs are effective in teaching us about structure and function, but they do little to overcome the pre-conditioned 'yuk' factor in most people. Several studies have demonstrated the importance of handling of dead or live specimens in assisting learning in school students, but contact with live animals fostered a deeper appreciation and positive attitude towards them (Sherwood *et al.* 1989; Hotchkiss 1991; Chilstrom 1993).

Ideally, a live invertebrate display would use appealing species to attract people to the display. The next step is to instil into them an awareness and appreciation of invertebrates as animals in their own right. This is followed by an educational programme that only uses locally available species (the 'nature in your own backyard' approach). This then leads to a greater understanding of local conservation issues, possibly including community action to conserve a threatened species of invertebrates (Yen 1993).

Conclusion

The importance of live invertebrate displays is gaining recognition. 'Invertebrates' was the main theme of a recent volume of the International Zoo Yearbook (Olney and Ellis 1991), and there is an annual conference in the United States on 'Invertebrates in Captivity' (Sonoran Arthropod Studies 1993).

Invertebrates are defined as animals without backbones. They could also be defined as animals in need of a good public relations company to assure that their importance is appreciated widely. The live invertebrate display, if designed in a balanced and unbiased manner, could well be that public relations company.

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Education: Improving the Image of Invertebrates

Carolyn Meehan[1]

Effective educational programs are needed if invertebrates, with their ecologically significant roles, are to be conserved. Much has been written about why invertebrates - animals without backbones - must be saved but holistic education is needed if it is to occur. This type of education teaches that the whole is greater than the sum of its parts and is based on the assumption that at some fundamental level everything in the universe is connected to everything else (Clark 1990).

Invertebrates have a Poor Image

The conservation of some species takes precedence over others in attention, time and money, as all species are not considered equal (Carson 1962). The conservation of invertebrates is largely over-

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looked and often neglected (Erzinclioglu 1990). Two barriers to their conservation are people's biased perceptions and their negative experiences with invertebrates.

Some people do not value invertebrates, believing that they have little worth and are not deserving of respect. Perceptions of invertebrates are biased by:

- the homocentric nature of humans that places undue emphasis on the importance of human;
- the view that nature is hierarchical and that humans represent the highest value in the phenomenal world (Nash 1989) thereby entitling them to 'manage' nature and
- the threat that the large number and small size of invertebrates pose to human notions of individuality and independence.

Similarly, people's experiences of, or interactions with, invertebrates are often negative because people relate to invertebrates in terms of their nuisance behaviour, pest status or threat of danger. Some insects transmit disease and some arachnids have deadly venom, but all invertebrates are often lumped together and beneficial species are not recognised or are simple ignored. Human space and habitations are often invaded by invertebrates in unexpected ways that put them beyond human control. Invertebrates are viewed as incapable of pain, rational consciousness or planned action (Kellert 1993) and people associate more closely with large animals, having what Wilson (1987) calls a 'search' image for them where people identify more readily with larger animals and understand their behaviour more easily.

Kellert (1993) has shown that higher education is closely associated with increased appreciation, concern and knowledge of biological diversity and conservation of invertebrates. Education is the key but a specific kind of education is needed to change people's perceptions and improve their experiences of invertebrates.

Holistic Education

Educational practices which view the world as a series of parts and then study these parts in isolation from each other have resulted in a negative image of invertebrates. In fact, people view invertebrates with aversion, fear and antipathy (Kellert 1993). Holistic education, on the other hand, considers all education to be environmental education.

Viewed holistically people are one of many species and are a part of nature, not apart from it. Increasingly, value is attributed to non-human organisms on the basis that their existence is in itself an expression of a continuing process of immense age and complexity. Such long standing existence in nature carries with it the unimpeachable right to continued existence (Erhlich 1985). An awareness of the intrinsic worth of other beings is steadily growing.

Invertebrates are essential for the survival of human beings. If people were to disappear tomorrow the world would go on with little change and Gaia, the totality of life on earth, would heal itself and return to a rich environmental balance (Wilson 1987). But if invertebrates were to disappear, people would not last more than a few months because the nutrient cycles, in which invertebrates play vital roles, would cease to function (Wilson 1987). Whilst holistically the objective is to value all species for their own sake, pragmatically the importance of invertebrates to people acts as a stronger motivation to protect them!

Negative experiences and biased perceptions of invertebrates are due largely to ignorance about their biology and behaviour. This ignorance promotes a sense of their strangeness which transmits into a fear of all species - harmless, beneficial and beautiful. Increasing knowledge about diversity of invertebrates provides opportunities for more positive interactions and allow an appreciation of individual species to be fostered.

With this increased knowledge, however, comes the responsibility to make sure that it is applied appropriately (Orr 1991) as knowledge cannot be considered to be complete until its effects on all communities, not only human, are known.

Once knowledge of the value and importance of invertebrates is known, actions, now and in the future, cannot be taken without consideration of the interconnectedness of all species and the effects each will experience.

Characteristics of Holistic Educational Programs

If invertebrate conservation is to be taken seriously, people need to be convinced of its necessity. Educational programs must focus on changing human attitudes and values regarding invertebrates through the acquisition of knowledge about them and positive interactions with them.

Environmental educational programs run by schools, local naturalist clubs and other educational institutions should have a number of characteristics that reflect a holistic focus to guarantee their success.

1. Invertebrates themselves are utilised as a tool to increase knowledge of form, function and habitat.
2. Participants learn about the beneficial nature of invertebrates to counteract previous 'bad press' and the vital ecological roles and aesthetic qualities of invertebrates are positively promoted.
3. Opportunities for participants to handle the animals in a controlled environment are provided. Physical contact, through handling, has long been understood to be a powerful method of learning: 'I hear and I forget; I see and I remember; I do and I understand' (Old Chinese Proverb). The keeping of invertebrates as pets is encouraged to create emotional links with these animals.
4. Information provided in the programs is relevant to the participants. Learning about the invertebrates from a local creek or roadway is more significance than learning about exotic species from other lands - although they too have their attraction and use.
5. Successful programs teach through example. Observing someone interact positively with an animal provides strong inducement to be involved and a subtle model for appropriate behaviour. Everyone is encouraged to actively participate and to learn from what is happening and from others.
6. The environment in which the program takes place is very supportive. Participants are challenged, not forced. Program experiences are consistently positive and the animals are promoted in the best possible light.
7. Effective programs stress the interconnectedness of invertebrates, people and other species, and discuss the relationships between them.
8. The language used is positive, never reactionary. In particular, the unconscious and often heard 'ugh' reaction is discouraged.
9. The results of the programs - information gathered, knowledge learned, appreciation gained - are shared as part of a network that assists scientific inquiry.

Summary

A holistic approach to biological education, emphasising the interconnectedness of nature, is essential if the problems of the next century are to be understood and solved (Robinson 1993). Humans need to re-evaluate their place in nature and the value they ascribe invertebrates, indeed all species. Until people recognise the intrinsic worth of invertebrates and value the roles they play in the environment, their conservation, and ultimately our own, is at risk.

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How the Community and Naturalists can Contribute to Invertebrate Conservation

Pat Vaughan[1]

Introduction

While certain groups of invertebrates are well known (such as the butterflies) and specific measures can be pursued for their conservation, most species are not well known and the only effective strategy for their conservation is the maintenance of the full range of habitats they rely upon.

Different invertebrates utilise different components of a natural habitat, so it is therefore important to maintain or provide these components, which include indigenous plants, leaf litter, fallen logs, dead trees, rocks, the soil itself and water bodies.Various processes can make an area unsuitable for resident invertebrates including weed invasion, changes to drainage patterns, the use of pesticides, and the presence of introduced animals, including introduced invertebrates such as the Honey Bee and European Wasp.

We must also be conscious of the potential changes to habitat arising from such global phenomena as changes to climate arising from the Greenhouse Effect and the damaging influence of ultraviolet radiation arising from Ozone depletion. The community's action in reducing its production of carbon dioxide, the other greenhouse gases, and the ozone depleting substances including chlorofluorocarbons, will be critical to the survival of plant communities and their resident faunas.

In general, individual actions that reduce energy utilisation, pollution production and natural habitat removal or degradation have the added bonus of being good for invertebrate conservation.

General actions

Given that so much land is in private ownership in Australia, the manner in which landowners manage their land becomes critical to the conservation of native species. While efforts have been made to ensure that all habitat types and their associated plants and animals are represented in reserves, this has not been achieved and protection on private land is essential to the survival of a great many species.

With the limited resources available to government conservation agencies, the voluntary work of community groups (especially Friends groups) has become an integral component of reserve management. Other groups working on river banks and other habitat remnants on public land outside the major reserves also make a substantial contribution to conservation.

Individuals working on their own land, particularly if they co-ordinate their activities with neighbouring properties as occurs with Landcare groups, are the most important ingredient of private land conservation efforts. Many landowners are now placing Conservation Covenants on their properties that protect existing natural habitat in perpetuity. These covenants which are organised through the Victorian Conservation Trust are placed on the title of the land and are binding on subsequent owners.

There is also an increasing participation by landowners in the Department of Conservation and Natural Resources Land for Wildlife Program. Those who manage their land such that it provides habitat for native wildlife are accepted into the program, receive a sign which they can display on their property, and receive the most up to date advice on wildlife management through a regular newsletter and notes on special topics.

The other area in which the community can assist in conservation is in the research area. Amateur naturalists, through

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recording the occurrence of species and noting their behaviour and habitat utilisation, provide additional useful information to that obtained by the limited number of professional researchers at institutions who are operating on limited resources. As one example, the rediscovery and subsequent protection of the Eltham Copper Butterfly, was due in large part to the efforts of amateur naturalists.

Community actions

Examples of direct actions by the community to protect a specific invertebrate arise in the case of the Eltham Copper Butterfly. These actions were diverse and involved individuals giving or doing according to their skills, time available or financial circumstances.

They included:

i the formation of the 'Friends of the Eltham Copper Butterfly', who produce a newsletter, run information stalls at community markets and festivals, and who undertake works such as weed and erosion control and planting at sites where the butterfly occurs;

ii individuals donating to an appeal the proceeds of which went towards acquiring a reserve for the butterfly;

iii artists donating works on the theme of the butterfly which were sold at a public auction, with proceeds going to the above appeal;

iv people (especially those living adjacent to butterfly reserves) planting indigenous species including Sweet Bursaria *(Bursaria spinosa)*, the host plant of the butterfly, and thereby providing additional potential habitat for the butterfly;

v individuals with the butterfly on their own land, observing the behaviour and ecology of the species and providing information useful to its conservation, and

vi individuals being involved in annual counts of the butterfly and thus assisting with the essential role of monitoring the size of populations and picking up early signs of problems at particular sites.

Similar actions could be pursued by individuals with any threatened species that occurs where they live. However a far greater proportion of the community undertake activities that are of benefit to a wide range of indigenous species rather than concentrating on one species.

Habitat rehabilitation works by Friends groups, Landcare groups and individuals are by far the most important in this regard. A steadily increasing proportion of the community is involved in such activities. In the Shire of Eltham alone, the number of Landcare groups has risen from one to twelve within a three year period, and given that rate of growth, every inch of the Shire should be covered by a Landcare or equivalent group by the turn of the century.

While much of the above activity is land based, a considerable proportion occurs along waterways and is of benefit to aquatic fauna. The Community Streamwatch Program initiated recently by Melbourne Water, supported by many Councils, and undertaken by schools and community groups, involves the monitoring of water quality in local streams. The monitoring involves the testing of physical characteristics such as turbidity, salinity and pH, but also involves sampling of aquatic macro-invertebrates. This will enable much more accurate targeting and effective implementation of conservation works by: providing information on the type and distribution of aquatic invertebrates; identifying stretches of waterways with pollution or other problems and increasing school and community involvement in works through their increased familiarity with, and concern for, aquatic invertebrates.

Individual actions

Obviously there is much the community can do for the invertebrate conservation. A summary of individual actions which will assist the conservation of native invertebrates is provided opposite.

* Retain existing native vegetation on your property. Native vegetation is what native invertebrates have evolved with and what best provides them with food, sites for reproduction and shelter. Many native invertebrates are totally dependent on one or a few native plant species;
* Retain a reasonable cover of leaf litter, fallen logs and rocks which provide habitat for specific invertebrates;
* Remove introduced invasive plants, as these displace indigenous plants utilised by native invertebrates, modify the physical structure of the habitat and its microclimate and soil chemistry.
* Plant local indigenous species on your property. A variety of publications are available to assist in the identification, propagation, germination and planting of indigenous plants (e.g. SGAP (1993), Costermans (1994)), and advice can be obtained from the Department of Conservation and Natural Resources and often from local Councils on plants appropriate to a given location. The plants used by host specific invertebrates such as butterflies are indicated in many publications (e.g. McCubbin (1971), Common & Waterhouse (1981).
* Join and actively participate in local Landcare and Friends groups or community environmental survey and monitoring programs.
* Learn more about local invertebrates through reading local publications or joining The Field Naturalists Club of Victoria, the Entomological Society of Victoria and local amateur naturalists groups.
* Generally be mindful of your lifestyle and its impacts in the natural environment and attempt to reduce your personal use of energy, production of pollution and your consumption of products that cause loss or modification of natural habitats.

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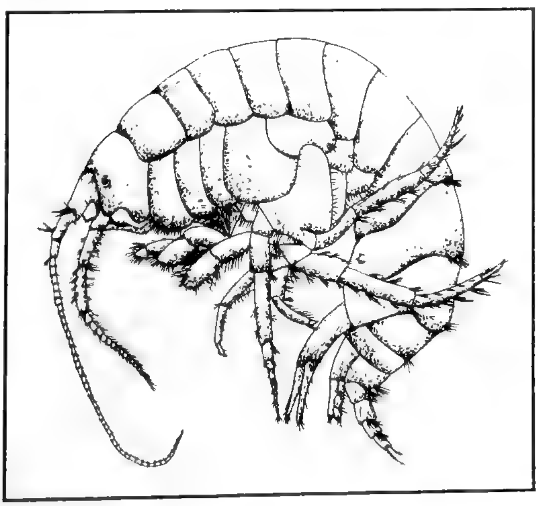

The Dandenong Freshwater Amphipod, *Austrogammarus australis*.

Hidden Rainforests.
Subtropical Rainforests and their Invertebrate Biodiversity

by G. Williams

Publisher: *New South Wales University Press, 1993. ISBN 0 86840 054 8.*

188 pp. RRP $79.95.

This splendid book is the result of many years study of a complex Australian environment, the subtropical rainforests of the Manning region of NSW, by Geoff Williams. The text and plates are evocative of his enthusiasm for the area and, for the first time, emphasise the major components of animal diversity - the invertebrates. As the author points out, these are generally dismissed in environmental planning and assessment programmes, and one important role of this book is to emphasise their diversity and ecological roles to conservation managers.

An introduction to rainforests in Australia is followed by a short chapter summarising knowledge of the region's vertebrate fauna. The next chapter, 'Rainforest Invertebrates', develops the major theme of the book - the vast array of 'lower animals' present and the central roles they play in sustaining ecological processes in the forests. The author's major interest, insects, are given prominence and the chapter includes a rounded discussion of the ecology of arthropods in rainforests, with numerous specific examples cited under a series of headings which range from purely taxonomic (various insect and other groups) to ecological ('Feeding strategies and adaptations') and faunistic ('Bees in rainforests', 'Composition of hemipteran fauna') - the sequence of topics is sometimes difficult to follow and I wondered if one 'hierarchical layer' of headings had been lost in production. Briefer treatments of other invertebrate groups follow, and most higher taxa are illustrated in the excellent composite colour plates of the book.

Building on this general appraisal, ensuing chapters detail the characteristics and biota of each of the major rainforest areas of the Manning catchment: littoral rainforest, riverine rainforest (Wingham Brush), additional riverine forests, Lansdowne - Comboyne Escarpment, additional rainforests, rainforests of the Gloucester Ridges (by Terry Evans), and Woko National Park. Each chapter summarises the peculiarities of the area, and readers unfamiliar with the region will be reassured by the series of photographs of major sites and habitats. A short chapter interspersed in this sequence deals with the complex topics of rainforest regeneration and rehabilitation, including the needs to control invasive weeds - such as *Lantana* - in disturbed forests. The book concludes with a series of appendices detailing plant and animal (mainly invertebrate) taxa recorded, and detailed captions to the 40 composite colour plates; a bibliography and index (reprinted by the publishers to replace the original incomplete version) complete the volume.

I found little to counter my initial highly favourable impression of this book. It is packed with information, but this is presented clearly and with adequate referencing, and is remarkably free of the usual scientific jargon which can frustrate readers. It is a solid introduction to the hidden fauna of rainforests, and deserves to be read widely by conservationists and naturalists in Australia and elsewhere both for itself and as an excellent example of an authoritative natural history book of great relevance in our rapidly changing world.

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Entomology

Ian Endersby[1]

Activities

As a Field Naturalist specialising in Entomology you can look forward to participating in:

Field collecting trips;
Identification of species;
Making your own insect collection;
Studies of life history and food plants (in the field or with captive specimens);
Distribution studies;
Insect behaviour and ecology;
Conservation of species and habitats;
Close-up photography.

Field guides/handbooks/ atlases

Butterflies of Australia. I.F.B. Common and D.F. Waterhouse. (Angus & Robertson).

Introductory Entomology for Australian Students T.R. New UNSWP, Kensington.

Handbook of Insect Collecting (Collection, Preparation, Presentation and Storage). Courtenay Smithers (Reed).

Australian Insects. John Child (Periwinkle Press). - out of print but often turns up in secondhand book shops.

The Insects of Australia 2nd edition (CSIRO). - the professional's bible.

Equipment

Nets for catching flying insects or for dredging in ponds and streams can readily be made from scrap materials as can pitfall traps. ***Portable fluorescent lights*** with a white backdrop sheet attract many species at night. ***Chemicals*** for killing and preserving insects can be obtained from specialist suppliers and so should proper entomological pins for setting insects for display. ***Setting boards*** can be made from balsa wood or some types of plastic foam and storage cases can be improvised, or made to a very high standard if woodwork is another of your hobbies.

You will soon find that a good ***hand lens*** of at least 10x magnification is almost a necessity to check small details on which species identification is based. If you do a lot of specialised identification a stereo dissecting ***microscope*** with at least 10x and 20x magnification and good lighting will make life very much easier.

Insect photography requires close-up equipment and macro-zoom lenses are now of high quality. Good, balanced lighting is essential so you will need flash-guns in your kit.

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Clubs and societies

Entomological Society of Victoria
Australian Entomological Society
Australasian Arachnology Association

Journals

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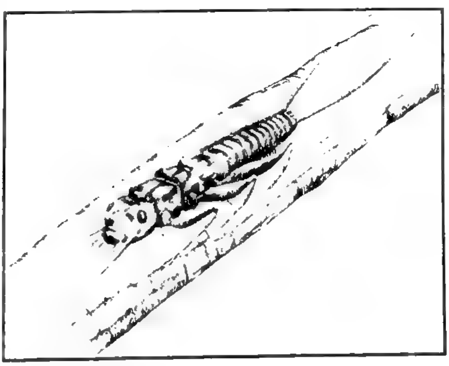

Nymph of *Eusthenia nothofagi*, the Otway Stonefly.

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Cover Photo: Peregrine Falcon chick in Victoria. *Photo by Ian Stevenson, Herald Sun,* Melbourne. (See article on page 100)

Recent Foraminiferal, Ostracodal and Molluscan Faunal Changes in a Short Core from Corner Inlet, Victoria

K.N. Bell[1], J.V. Neil[1] and R. Burn[1]

Little is known about the faunal changes with geological time in the Recent Victorian marine faunas. Sea-level changes have a considerable effect both on coastal processes and the living biota. In the geological past sea-level changes have occurred as a result of eustatic and tectonic changes. In southern Australia sea-level reached its peak about 6000 years ago at about 1-2 m above present levels (Bryant *et al.* 1992; Gill and Lang 1982) and has since then remained at about present levels. This means that at any given site on the coastline the water depth, and the associated temperature and salinity, may have changed over time and so has provided a changing environment for the marine fauna at that site. A sediment core taken at any site can therefore indicate what changes in the environment may have occurred and by analysing the fauna present at different depths within the core these changes can be estimated.

The present study was undertaken on a short core (350 mm long) from Corner Inlet, Victoria (Fig. 1). Three marine invertebrate groups (foraminiferans, ostracodes and molluscs) were investigated to see what, if any, faunal changes had occurred during the short time span represented by the core and what palaeoenvironmental deductions could then be made. No absolute dating has been undertaken on the core but a time span of the order of 1-2000 years has been suggested by comparison with other Corner Inlet cores (*pers. comm.* to K.N. Bell from W.-Y. Zhuang, A.N.U., 1988), assuming little erosion or reworking of the sediments had occurred as would be expected in such a protected, low energy environment.

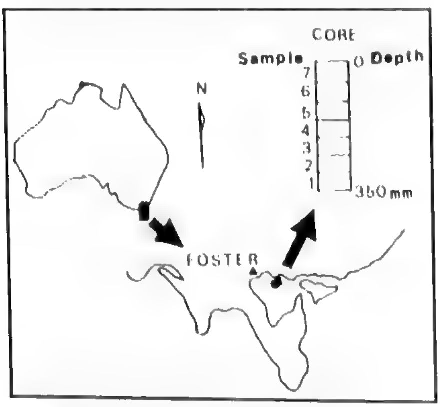

Fig. 1. Locality map showing core position and numbering of core samples.

[1]Honorary Associates, Museum of Victoria, Swanston St., Melbourne, Victoria, 3000.

Corner Inlet is a large estuarine area on the north coast of Wilson's Promontory. It consists of extensive sand and mud flats either exposed or barely covered at low water and is dissected by five major tidal channels which range to about 20 m deep (Jenkin 1968).

The core reported on here was taken about 300 m offshore at Foster Beach (Fig. 1) at an extremely low tide (5 March 1987) when the sandy mud flats in the area were exposed.

Methods

The core was taken by simply pushing a length of 50 mm PVC pipe into the sediment, with the upper end plugged with a sliding stopper and then extracting the tube. The enclosed core was slowly extruded and cut into 50 mm long sections (samples 1-7; Fig. 1). Each section (of approximately 100 ml) was boiled in water with a small amount of Calgon and washed over a 0.063 mm aperture sieve.

The similarity (or dissimilarity) between any two samples can be estimated by using Sanders' method (Sanders 1960); for each species common to the two samples being compared, the lower of the two percentage occurrences is taken and then the values totalled to give the Sanders' similarity coefficient. Total values greater than 80% are usually taken to indicate that the samples are nearly identical; lower values indicate greater dissimilarities.

The faunal diversity, N_{95}-value, is a measure of the number of species making up 95% of the fauna; these values have the same environmental significance as the total number of species but are not affected by those occurrences of rare species that constitute fractional percentages of the total populations (Walton 1964). A relative change in the number of species or N_{95}-value has environmental significance: a decrease in numbers of species or N_{95}-value in successive samples in a core indicates a marine regression, an increase in values indicates a marine transgression (Walton 1964).

Description of the core

The total length was 350 mm. The top 3-5 mm consisted of clean sand clearly demarked from the remainder which was a dark grey to black sandy mud with a small amount of shell debris present. Upon drying this colour changed to pale grey. There were no obvious layers or laminations in the core and no indications of bioturbation. Upon washing, all samples readily disaggregated and, when sieved, left a remainder (varying from 5 to 20 g) of angular quartz grains, fragments of muscovite and rare biotite, with abundant foraminiferans and ostracodes and a sparse bivalve and gastropod fauna.

The high proportion of silt/mud in the core samples and the lack of plant detritus would indicate that sedimentation took place near, but not necessarily on, seagrass flats which, in Corner Inlet, are most efficient traps of fine-grained sediment compared with the bare sandy areas (Zhuang and Chappell 1991).

Results

Foraminifera (author K.N. Bell):

A total of 3,959 specimens belonging to 69 species of benthic and two species of planktic foraminiferans were identified from the core (Table 1). Of these, 18 species occurred in most samples, the remainder only in small numbers throughout the middle section of the core. Three species (*Brizalina* sp., *Cibicides biserialis* and *Planodiscorbis planoconcava*) were found only in the topmost sample.

The fauna was dominated by miliolid (9 spp.) and elphidiid (8 spp.) forms. Only one

Table 1. List of Foraminiferans found in the core*

FORAMINIFERANS (KNB)			
Ammobaculites sp.	*Elphidium limbatum*	*Miliolina labiosa*	*Sigmoilina australis*
Ammonia aoteanus	*E. macellum*	*Nodosaria* sp.	*Spirolina inaequatis*
Amphistegina sp.	*E. macellum aculeatum*	*Nonionella auris*	*Spiroloculina communis*
Brizalina spathulata	*E. simplex*	*Nubecularia lucifuga*	*S. aequa*
Cibicides biserialis	*Glabratella australiensis*	*Oolina gibbosa*	*Textularia sagittula*
Cymbaloporetta bradyi	*Guttulina lactea*	*Planodiscorbis planoconcava*	*T.*sp.
Discorbis sp.	*G. pacifica*	*Planorbulina mediterraniensis*	*Triloculina oblonga*
Eggerella bradyi	*G. regina*	*Quinqueloculina lamarckiana*	*T. trigonula*
Elphidium advenum	*G. yabei*	*Q. poeyanum*	*Trochammina inflata*
E. crispum	*Lagenid* spp., (21 spp. of Lagena, Fissurina, Oolina Dentalina, usually only as single specimens).	*Q. seminulum*	*Vertebralina striata*
E. depressulum	*Lamellodiscorbis dimitiatus*	*Q. subpolygona*	
E. granulosum	*Leptohalysis* sp.	*Reophax barwonensis*	Planktic species: *Globigerina* spp.
E. gunteri corioensis	*Massilina* sp.	*Rosalina australis*	

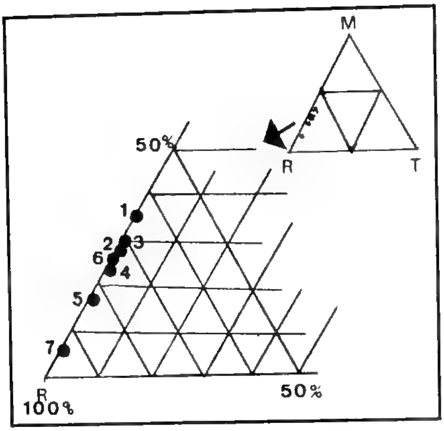

Fig. 2. Miliolid:Rotaliid: Textulariid ternary diagram, showing the relative percentage composition of the samples.

miliolid, *Quinqueloculina seminulum*, occurred in the surface sample, whilst four species of *Elphidium* (*simplex, crispum, gunteri corioensis* and *advenum*) were present in this sample. The other representatives of these genera ranged throughout samples 2-6 except *Q. lamarckiana* (sample 1 only), *Q. subpolygona* (sample 4) and *Sigmoilina australis* (samples 2 and 3).

Agglutinated species were uncommon (seven species in four genera), none of which were typical of lacustrine or marginal marine conditions but which are found elsewhere in Victoria in protected marine environments.

Planktic specimens were very rare and found only in sample 5, one specimen; samples 2 and 7, two specimens each and sample 4, six specimens.

The lagenid fauna comprised 21 species; they were present usually only as single species and specimens in the samples, except for sample 4 in which 12 species occurred. Using the relative percentages of the miliolid, rotaliid and textulariid groups present, the triangular M:R:T: plot (Fig. 2) shows the samples fall on, or close to, the M-R side and within the normal marine lagoon zone of Murray (1973).

The Sanders similarity coefficient between all pairs of samples showed that samples 2 and 6 (82%), 3 and 2 (81%0), 3 and 4 (85%) and 2 and 4 (81%) could be considered identical; the other samples had values ranging between 54% and 79%.

The Fisher α-index (see Murray 1973), the number of species and the N_{95}-value all show the same variation (Fig. 3) - increasing values from sample 1 to 4 then a decrease to sample 7.

Of the 69 benthic species recovered only eight were present in numbers greater than about 3% of the fauna of each sample. *Ammonia aoteanus* remained the dominant species and relatively constant throughout the core. *Quinqueloculina seminulum* and *Triloculina oblonga* showed a steady decline up the core. The elphidiids showed varying changes: *Elphidium advenum* and *E. crispum* decreased in relative percentage from sample 1 to 4 and then increased again; *E. limbatum* increased in relative percentage from sample 1 to 4 and the decreased whilst *E. simplex* increased with time. *Spiroloculina aequa* remained fairly constant from samples 1 to 6 but then disappeared completely in the topmost sample.

Ecological inference

These changes can be most easily explained by a simple deepening of the water from samples 1 to 4 and then a consequent shallowing to the present day. By comparison with known Victorian faunas, the middle core samples (Samples 3-5) at Foster Beach are comparable with Collins' Lower Bay fauna in Port Phillip Bay in depths of 5-25 metres (Collins 1974), and especially with the semi-marine fauna of the Reeve Channel (depths of 10-12 m) connecting the main

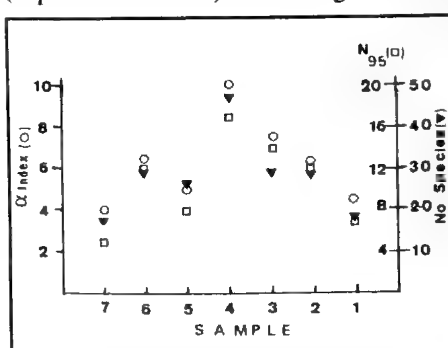

Fig. 3. Foraminiferal α-values, N_{95}-values and number of species found in each sample.

Table 2. List of Ostracodes found in the core*

OSTRACODA (JVN)			
Polycope sp.A..	*C.* sp. nov.	*Doratocythere* sp	*X.estoleberis limbata*
P. sp.B	*C.* sp.	*Arculacythereis* sp.	*X. onslowensis*
Cytherella sp.A.	*Tanella gracilis*	*?Keijella* sp.	*X. chilensis*
C. sp.B	*Paracytheroma* sp.	*Mutilus pumila*	*X.* sp.1
Neonesidea sp.	*Eucythere* sp.	*Aurila* sp.	*X.* sp.2
Paranesidea sp.	*Australocytheridea vandenboldi*	*Bradleya* sp.	*Microxestoleberis* sp.
?Rhombonesidea sp.	*Cyprideis australiensis*	*Jugocythereis henryhowei*	*?Bythocythere* sp. A.
Anchistrocheles sp.	*C.* sp. nov.	*J.* sp	*?B.* sp. B.
Bythrocypris sp.	*C.* sp.	*Quadracythere obtusalata*	*?Retibythere* sp.
Osticythere baragwanathi	*Parkrithella australiensis*	*Loxoconcha australis*	*Dentibythere dentata*
Hemicytheridea sp.	*Copytus* sp. A.	*L. trita*	*D.* sp.
Loxocythere hornibrooki	*C.* sp. B.	*L.* sp.nov.	*Paradoxostoma* sp. A.
Microcytherura sp.	*Cythereis* sp.	*L. abditocostata*	*P.* sp. B.
Schizocythere sp.	*Australimoosella liebaui*	*L.* sp.	*Cytherois* sp.
Neomonoceratina koenigswaldi	*Ponticocythereis* sp.	*Loxoconchella pulchra*	*?Macrocyprina* sp.
Mackenzieartia portjacksonensis.	*Yassinicythere bassiounii*	*Cytherura* sp.	*Propontocypris* sp.
Pectocytherinid indet.	*Mackencythere venata*	*Hemicytherura spinifera*	*Aglaiocypris* sp.
Leptocythere hartmanni	*Pterygocythereis* sp. s.l.	*Semicytherura* sp.	*Phlyctenopora zealandica*
Callistocythere purii	*?Notocarinovalva* sp.	*Cytheropteron* sp.cf.*C. whitei*	*P.* sp.
C. insolita	*Echinocythereis melobesiodes*	*Cytheropteron* sp.	*?Pseudaurila* sp.
C. sp.cf.*C. windangensis*	*?Echinocythereis* sp.	*Xestoleberis cedunaensis*	*plus 11 indeterminate species.*

lakes with the sea at Lakes Entrance (Apthorpe 1980). As Corner Inlet has major tidal channels at present, the depth changes postulated above can be explained by the migration of a channel into the Foster Beach area and then its subsequent movement away.

Ostracoda (author J.V. Neil):

From the seven samples in the core a total of 1,802 specimens was picked, representing 93 species from 59 genera (Table 2). These were distributed in generally increasing totals for each sample from the oldest (bottom of the core, sample 1: 124 specimens) to the youngest (top of the core, sample 7: 415 specimens). Of these species, 26 occur commonly throughout the core, whilst 24 species occur in only one sample each, generally with only one or two specimens.

The fauna is characterised by the occurrence of six species, each of which constitutes 5% or more of the total number of specimens. These are:

Mackenzieartia portjacksonensis
235 specimens (13%)

Loxocythere hornibrooki
159 specimens (8.8%)

Pterygocythereis sp. s.l.
120 specimens (6.7%)

Australocytheridea vandenboldi
110 specimens (6.1%)

Loxoconcha australis
106 specimens (5.9%)

Xestoleberis sp.1
97 specimens (5.4%)

These species constitute 45.9% of the total number of specimens. Of the remaining species only *Aglaiocypris* sp., *Yassinicythere bassiounii* and *Loxoconcha abditocostata* are common. If the characteristic genera, rather than the species, are identified using the same criterion (5% or more of the fauna) then the same six appear but *Xesteroleberis* and *Loxoconcha* are second and third most abundant after *Mackenzieartia*. These six most common genera constitute 56.3% of the total number of specimens.

The diversity of the samples as measured by Fisher's α-index ranges between 13 and 20, with no clear trend evident. As is usually the case when using this measure of diversity with ostracode faunas, the figures are consistently higher than for the foraminifera. The similarities between the faunas from each of the samples were measured using Sanders' coefficient (Murray 1973). No pair of samples could be described as identical (i.e. with a coefficient of 80% or more). The coefficients ranged between 41.5 and 73, so that the group could be described as somewhat disparate in terms of faunal similarity.

Ecological inferences

The most abundant genera and species suggest a shallow estuarine to marine lagoon environment over the whole of the period of time represented by the core. The abundance of *Mackenzieartia portjacksonensis* points to a muddy substrate (Yassini and Wright 1988). Whilst there is an increase in the dominance of this species from 7% in sample 1 to 20% on sample 7, it is not possible to infer any clear trends in the nature of the substrate since the evidence of the other species is equivocal in this regard. Another commonly occurring species, *Australocytheridea vandenboldi*, which Hartmann (1980) also recorded from nearby Port Welshpool, reinforces the inference of a smooth substrate (Hartmann 1980).

The presence of several species of Xestoleberididae and Loxoconchidae throughout the core indicates a continuing phytal association in the environment, probably with seagrass. *Loxocythere hornibrooki* which shows a somewhat similar distribution through the core as *M. Portjacksonensis*, has been recorded by Hartmann (1980) from Port Welshpool in sand/mud shallows with seagrass, so that the presence of that species strengthens the inferences based on the other commonly occurring species.

It is not possible to draw any inference of change through time in the environment in which these ostracode faunas lived. Unlike the evidence from the foraminiferans, which relate quite specifically to depth of habitat, the evidence from the ostracodes does not give any useful information about changes in depth. However, some additional information is provided by the occurrences of some significant species in small numbers in the samples. *Osticythere reticulata*, which occurs in all samples except number 4 (though in small numbers) is an indicator of marginal environments such as estuaries and shoreline lagoons. Its favoured substrates are shallow sands, silts and muds, especially when organic detritus is present (McKenzie and Pickett 1984). The euryhaline *Cyprideis australiensis*, *Loxoconcha australis* and *Phlyctenopora zealandica* all indicate the likelihood of salinity fluctuations. *Paracytheroma* sp. cf. *P. sudaustralis* occurs throughout the core and is also indicative of marginal environments, possibly with some freshwater influence. The occurrence of *Tanella gracilis* and *Loxoconchella pulchra* which favour sandy substrates (McKenzie and Pickett 1984) is a slightly anomalous feature.

Some difficulty in drawing valid ecological inferences from the occurrence of certain ostracode species in the fauna is exemplified by *Yassinicythere bassiounii.* Yassini and Kendrick (1988) refer this species to high energy environments, whereas Hartmann (1982) says it prefers warm, calm waters. However, in general terms, it can be suggested that the Corner Inlet environment has not shown marked changes in substrate, water temperature and phytal associates over the period of time covered by the samples. Salinity fluctuations have probably occurred, with freshwater influence from the discharge of nearby streams being a major factor in this. The depth changes inferred from the foraminiferal evidence are not substantiated by the ostracode fauna. The disparate nature of the ostracodal faunas from the samples when compared with each other, is to some extent paralleled by the foraminiferal faunas. The variations appear likely to be due to varying depositional and winnowing effects in the channels which wander over this area through time, rather than to any substantial changes in the environment itself.

Yassini and Kendrick (1988, p.119) suggest some correlations between numbers of ostracodes (and foraminiferans) and two transgressive phases in the Swan River Estuary near Perth. In the Initial Phase of transgressive-lagoonal character, there were low energy levels, bioturbation and fluctuating concentrations of dissolved oxygen and salinity correlated with low densities of ostracodes and foraminiferal populations. The Second Phase, also transgressive, was marked by higher energy levels and strong, sporadic salinity variation correlated with high density ostracode and foraminiferal populations. The increase in density of the ostracode populations from oldest to youngest samples from Corner Inlet may reflect similar influences to those on the Swan Estuary.

Mollusca (author R. Burn):

The molluscan record from the core is sparse: 324 specimens or fragments representing 72 species (Table 3). Three bivalves, *Electroma georgiana* (6.2%), *Cavitidens omissa* (4.9%) and *Cyamiomactra mactroides* (7.4%) are present in all samples, and seven bivalves and 18 gastropods, including one live-taken species in the topmost sediment, are represented by single specimens (7.7%).

Electroma georgiana is a fragile epiphytal species; its presence in all samples suggests nearby long-term beds of seagrasses and algae in shallow (0-5 m) protected waters.

Table 3. List of Mollusca found in the core*

MOLLUSCA			
Gastropoda:	*Odostomia australis*	*plus 17 indeterminate* spp.	*Legrandina bernardi*
Patelloida profundior calamus	*Cingulina spina*	***Bivalvia:***	*Cyamiomactra balustrina*
Naccula parva	*Linopyrga brevis*	*Nucula pusilla*	*C. communis*
Lissotesta porcellana	*Egila mayi*	*Philobrya (Micromytilus) francisensis*	*C. mactroides*
Munditia subquadrata	*Koloonella minutissima*	*Musculus cumingianus*	*Condylocardia* sp.
Diala suturakis	*K. moniliformis*	*Electroma georgiana*	*Salaputium micrum*
Alaba translucida	*Chemnitzia mariae*	*Limatula strangei*	*Paphies (Amesodesma) angusta*
Eatoniella melanochroma	*Retusa chrysoma*	*Ostrea angasi*	*Hiatella australis*
Crassitoniella erratica	*Chlichna thetidis*	*Linga (Bellucina) praetermissa*	*Barnea australasiae*
Hydrococcus brazieri	*Tornatina* sp. *(live taken)*	*Anodontia (Cavitidens) omissa*	*plus 13 indeterminate* spp.
Lironoba australis	*Cylichnatys campanula*	*Arthritica semen*	
Leucotina sp.	*Haminoea maugeansis*	*Mysella donaciformis*	

Barnea australasiae bores into relatively hard clay-like sediments at and below low tide level. The older samples (1-4) contain specimens suggesting exposures of suitable sediments along the sides and bottoms of nearby channels.

Paphies angusta (sample 2), *Legrandina bernardi* (samples 1,5), *Mysella donaciformis* (samples 1-5,7) and *Haminoea maugeansis* (sample 5) all occur in lower intertidal/upper subtidal areas, hence the idea that these samples represent times of shallow or lower intertidal waters. *Arthritica semen* (sample 6) and *Hydrococcus brazieri* (samples 1, 3) today both live in marginal marine environments, suggesting very shallow, perhaps upper intertidal conditions existed nearby. *Cylichna thetidis* is a deeper water (3 m) infaunal species; its presence at sample 4 suggests this was a time of greater water depth. The absence of the three shallow water/lower intertidal bivalves *L.bernardi, M. donaciformis*, and particularly *P.angusta*, from sample 4 tends to confirm the deeper water conditions existing at that time. The limpets *Naccula parva* and *Patelloida profundior calamus* are both shallow subtidal species, the former living on sea grasses, the latter on hard substrates such as live and dead shells and rock. Their occurrence in sample 2 perhaps indicates a slightly deeper water habitat, possibly not as deep as sample 4.

Ecological inferences

The molluscs in the samples appear to represent the following sequence of marine conditions:

sample 7 - shallow, marine
sample 6 - shallow, marine
sample 5 - very shallow, marine
sample 4 - deeper, perhaps in excess of 3 m, marine
sample 3 - very shallow, marginal
sample 2 - a little deeper, more marine
sample 1 - very shallow, somewhat marginal.

Overall, a fairly stable marine environment is suggested for the time taken to lay down the depth of the core, with minor sea-level fluctuations producing marginal marine conditions, perhaps in shifting channels due to increased currents, at times of higher sea-levels.

Other Material

Spines from the heart urchin *Echinocardium* are present in large numbers in all samples, pointing to the presence of nearby soft, fine, muddy sub-tidal conditions.

Charred wood fragments are a feature of samples 3 and 5. These could have entered the samples from local bushfires, either by wind action on to exposed low tide sandflats, or by runoff from nearby land into streams and washed out to sea at times of subsequent rains.

** Further details of the distributions of the three invertebrate groups within the core may be obtained from the respective author.*

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The Growth and Development of the Eastern Barred Bandicoot *Perameles gunnii* in Victoria

Anthony C. Dufty[1]

Abstract

A growth curve of head length provided a means of assessing the age of *Perameles gunnii* from birth to four months. Measurements of body weight were used to detemine the age of bandicoots to 10 months. The development of neonates to emergent pouch young is described. Juvenile *P. gunnii* may emerge for short periods after 46 days of pouch life and re-enter the pouch until day 53. Weaning of offspring occurs when young are between 50 and 57 days old. Juvenile *P. gunnii* that have emerged from the pouch may remain dependent on their mother for some time. Offspring that were aged between 57 and 86 days were observed associating closely with their mother during her nocturnal foraging. *Perameles gunnii* aged between three and six months and independent of their mothers were referred to as subadult. Hence, three developmental stages were recognised for *P. gunnii*: juvenile (0 - 3 months), sub-adult (3 - 6 months), and adult (greater than six months).

Introduction

The comprehensive description of a population's demography depends largely on the ability to accurately determine the age of individuals. For endangered species, age determination and subsequent life-table analysis can be used to calculate population viability and age-specific rates of reproduction and survival and highlight actions that will most effectively lead to population or species recovery. The remnant mainland population of the Eastern Barred Bandicoot, *Perameles gunnii* is highly endangered and persists only at Hamilton, Victoria (Brown 1989).

During recent live-trapping studies in Victoria, the age structure of the population of *P. gunnii* at Hamilton was arbitrarily estimated using body weight; individuals that weighed more than 500 g were described as adult (Brown 1989; Minta *et al.* 1990; Dufty 1991 *a*). In Tasmania, Heinsohn (1966) defined male and female *P. gunnii* that were six and four months respectively as adult and based his estimates on a combination of head length and body weight. Despite these definitions, no standard method of ageing *P. gunnii* exists.

This paper examines weight and morphometric data collected during recent monitoring of a captive breeding colony of *P. gunnii* at Gellibrand Hill Park in order to develop a means of assessing the age of *P. gunnii*. This information was then applied to data from the free-ranging population at Hamilton and the captive breeding colony at Gellibrand Hill Park to describe the growth and development of *P. gunnii*.

Methods

Weekly and bi-weekly monitoring of a captive breeding colony at Gellibrand Hill Park between August 1988 and December 1989 allowed regular measurements and observations of pouch young to be made. The growth and development data for free-ranging *P. gunnii* was recorded during monthly live-trapping at the Hamilton Municipal Tip between 1989 and 1990 (Dufty 1994 *b*). Measurements of growth (to the nearest 0.1 mm using dial calipers) and observations of development of pouch young were undertaken *in situ*. No litters that were examined at Hamilton were assumed to include neonates (between 1 - 5 days old). The age of young *P. gunnii* observed at Hamilton was estimated from growth curves of head length and body weight that were constructed from data collected at Gellibrand Hill Park.

Avoidance behaviour is commonly observed between *P. gunnii* of different ages and sexes (Dufty 1994 *a*). Hence, adult females that were observed to be associating closely with young (e.g. an adult female and young that were live-trapped together) but displayed little or no antagonism toward them, were assumed to be the mother of the

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young. Young that had emerged from the pouch but were associating closely with an adult female were referred to as post-emergent dependent juveniles. Standard measurements of head, ear, foot, tail and scrotum (Brown 1989; Dufty 1991 *a*; 1991*b*) were recorded for juvenile, subadult and adult *P. gunnii*.

Results

Growth curves for head length and body weight were plotted from 58 encounters of 12 litters (totalling 33 individuals) that were first recorded as neonates at Gellibrand Hill Park (Fig. 1and 2). These growth curves, and the morphometric data collected in the field,

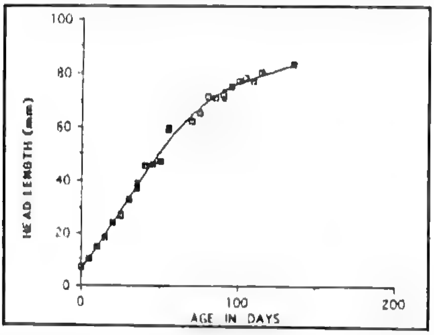


Fig. 1. The growth in head length of 33 *Perameles gunnii* that were first encountered as neonates in the captive breeding colony at Gellibrand Hill Park, Victoria. Values are means ± standard error and line of best fit was plotted from a polynomial equation to the order of 3 (y = 4.84 + 1.06x - 0.003x^2 - 5.88e - 6x^2 R = 1.0).

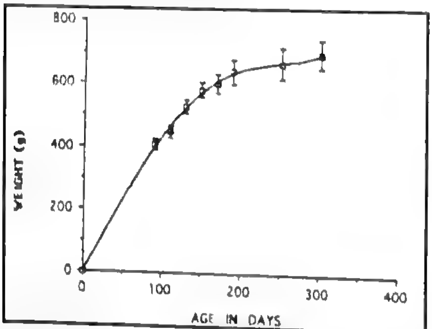


Fig. 2. The growth in body weight of 33 *Perameles gunnii* in the captive breeding colony at Gellibrand Hill Park, Victoria. Values are means ± standard error and line of best fit was plotted from a polynomial equation to the order of 4 (y = 0.32 + 4.51x - 0.006x^2 - 1.02e - 4x^3 + 0.0e + 0x^4 R = 1.0).

allowed the age of a further 145 young in 66 litters observed at Hamilton to be estimated. Also, ten juveniles (in eight litters) were caught in the same trap as their mothers and their body weight, morphology and behaviour were recorded. Hence, the growth of 188 young in 86 litters from both captive and free-ranging populations was reported (Table 1 and 2), and of these, the development of 27 pouch young in 13 litters was described (Table 3).

Description of neonate

Two litters of neonates totalling seven *P. gunnii* were known to be born within 24 h of examination and were described *in situ*. The mean head length was 5.75 mm (n=7) and mean crown-rump length was 13.6 mm (n=7). Neonates were reddish-pink in colour with hairless, glossy skin that was slightly moist to touch. The mouth comprised a circular opening firmly enclosed upon a teat by an enlarged tongue that slightly protruded from the mouth. The nostrils were tubular and prominent on an abruptly ending snout. The eyes were represented by dark grey pigmentation that formed a ring under a translucent membrane. Neither ears nor sex was distinguishable. The forelimbs were well developed, with three toes on each limb, compared to the hind limbs that resembled flippers with two rudimentary digits on each. The tail was well developed and about 3 - 4 mm long, curving ventrally between the hind limbs. The neonates often moved during the examinations. In general, the forelimbs moved randomly while the hindquarter moved more saltatorially with the curved spine straightening as the hind limbs pushed backwards.

Description of emergent pouch young

The oldest pouch young observed were estimated to be 53 days old. The mean head length and body weight of emergent pouch young (between day 46 and 53) were 47.2 mm (n=10; range 49 - 44 mm) and 81.4 g (n=4; range 140 - 42.5 g) respectively. Their ears were erect, facing forward and 28.1 ± 0.2 mm (n=2) high and their tail was 49.2 ± 0.7 mm (n=2) long. The young's eyes were open, all whiskers were present and fur covered the body to a length of 5 mm. The

Table 1. Growth of head length, foot length and body weight for 145 pouch young in a free-ranging population of *Perameles gunnii* at Hamilton, Victoria. Values are means ± standard errors with the

Age (days)	Head length (mm)	Foot length (mm)	Body weight (g)	Age (days)	Head length (mm)	Foot length (mm)	Body weight (g)
1	5.8 ± 0.1 (2)			27	25.8 ± 0.2 (3)	16.6 2.4 (2)	
2	6.5 ± 0.0 (3)			28	26.8 ± 0.8 (2)	19.3 ± 1.6 (2)	
3	7.2 ± 0.3 (2)			29	27.0 ± 0.5 (2)	16 (1)	
4	8.0 (1)			30	29.0 (1)		
5	8.4 ± 0.1 (4)			31	29.6 ± 0.2 (5)	19.1 ± 1.2 (5)	
6	8.8 (1)			32	32.3 ± 1.3 (2)	25.0 ± 0.5 (2)	
8	9.3 ± 0.3 (3)			34	32.6 ± 0.1 (2)	24.9 (1)	
10	10.5 ± 0.2 (6)			35	34.5 (1)	30.5 (1)	
11	12 ± 0 (3)			36	34.7 0.2 (3)	28.0 4.0 (3)	
12	12.5 ± 1.5 (2)			38	36.9 ± 0.5 (2)	31.3 ± 4.6 (2)	
14	14 (1)			42	40.7 ± 0.3 (3)	34.2 ± 1.0 (3)	30.0 (1)
15	14.8 ± 0.7 (3)	6.4 ± 1.4 (2)		44	44.3 0.8 (2)	41.8 0.3 (2)	70.0 (1)
16	16 (1)	6 (1)		45	43.8 (1)	38 (1)	
17	16 (1)	7 (1)		46	44 (1)	42 (1)	
18	17.4 ± 0.4 (7)	8.4 ± 0.6 (7)		47	44.8 (1), 41.5 (1)	66.0 (1)	
19	19.3 ± 0.8 (2)	9.5 ± 1.5 (2)		48	47.0 ± 0 (2)	46.8 ± 1.3 (2)	77.0 (1)
21	21.4 ± 0.3 (5)	11.7 ± 0.7 (3)		49	48 ± 0.5 (2)	46 ± 0.5	
22	22.7 ± 0.5 (3)	12.3 ± 0.5 (3)		50	48 ± 0.5 (2)	41.8 ± 3.75 (2)	42.5 (1)
24	22.5 ± 0.5 (2)	14.5 (1)		51	48.2 (1), 48.1 (1)	140 (1)	
25	23.8 ± 0.8 (2)	12.4 (1)		53	49 (1), 45 (1)		
26	25.5 (1)	18.8 (1)					

fur was very fine and soft to touch and pigmented a golden brown with distinct cream and dark patches that delineated bars on their hindquarters. The young were often found detached from a teat (one young was observed suckling two teats simultaneously) and were sometimes heard making soft squeaking noises. During examinations, the young were very curious and often sniffed and nuzzled objects e.g. fingers placed within the pouch. During this time, young may voluntarily emerge for short periods and later re-enter the pouch. On one occasion, after both mother and young were crouched on the trap floor, the young was observed re-entering the pouch. As the trap was approached, the mother raised herself to a standing position, arched her back and lifted her left forelimb to expose the pouch. The young promptly re-entered the pouch while the mother maintained her vigil. The age of the young was estimated to be about 53 days.

Description of post-emergent dependent young

Although not observed during the study, emergent young were probably left in a nest during the mother's nocturnal foraging. Many adult females were observed lactating, having greatly extended nipples, about 40 mm long, but without pouch young. This period of lactation when pouch young were absent, occurred between pouch emergence (day 53) and day 57. Eight post-emergent juvenile *P. gunnii* were captured with their mothers. The youngest of these juveniles was estimated to be 57 days while the oldest was 86 days. All mothers that were caught with post-emergent juveniles were not lactating or lactated with very immature young. Therefore, *P. gunnii* appeared to be weaned off milk by about day 57 but still depended on their mothers to find solid food. The

Table 2. Mean size of live-trapped juveniles (aged 0 - 3 months), subadults (aged 3 - 6 months) and adults (aged 6 months or older), excluding pouch young, in a free-ranging population of *Perameles gunnii* at Hamilton, Victoria. Mean values are ± standard error.

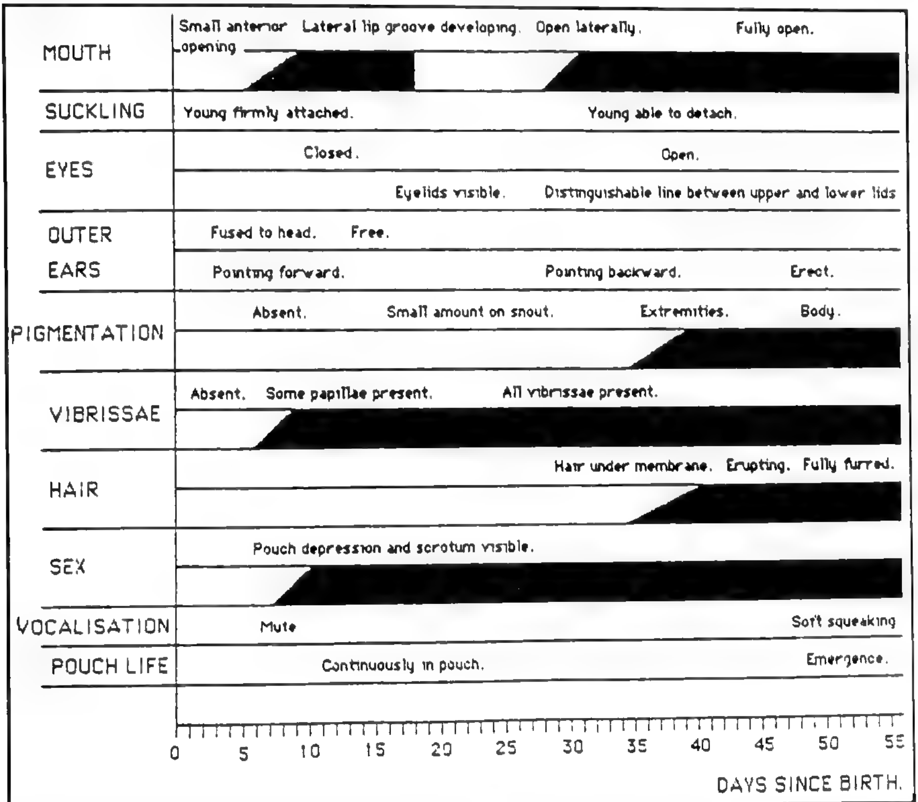
Characteristic	Mean size	Number	Minimum	Maximum
a) Juvenile				
Body weight	286.4 ± 29 g	18	135 g	480 g
Head length	65.1 ± 1.4 mm	18	53.0 mm	73.8 mm
Foot length	62.6 ± 1.2 mm	15	54.0 mm	68.7 mm
Ear length	37.9 ± 1.6 mm	18	31.8 mm	44.8 mm
Tail length	71.3 ± 2.6 mm	11	53.5 mm	83.5 mm
Scrotal length	11.7 ± 1.1 mm	9	7.8 mm	18.2 mm
Scrotal width	13.8 ± 1.4 mm	9	9.0 mm	21.8 mm
b) Sub-adult				
Body weight	546.9 ± 9.9 g	34	405 g	640 g
Head length	79.8 ± 0.6 mm	30	74.5 mm	89.0 mm
Foot length	70.1 ± 0.5 mm	30	66.0 mm	75.0 mm
Ear length	42.3 ± 0.7 mm	30	35.0 mm	47.0 mm
Tail length	83.6 ± 1.3 mm	27	73.8 mm	97.9 mm
Scrotal length	19.6 ± 1.4 mm	11	12.0 mm	26.5 mm
Scrotal width	23.4 ± 1.6 mm	11	13.3 mm	29.5 mm
c) Adult				
Body weight	805.8 ± 4.8 g	236	645 g	950 g
Head length	86.9 ± 0.2 mm	225	78.4 mm	95.2 mm
Foot length	75.1 ± 0.2 mm	223	68.0 mm	81.5 mm
Ear length	45.9 ± 0.2 mm	222	38.5 mm	52.0 mm
Tail length	91.6 ± 0.4 mm	184	75.0 mm	105 mm
Scrotal length	27.9 ± 0.2 mm	136	21.7 mm	33.0 mm
Scrotal width	33.1 ± 0.2 mm	136	26.3 mm	39.2 mm

average head length and body weight of the live-trapped post-emergent dependent juveniles were 59.9 mm (n=8; range 70 - 53 mm) and 161.4 g (n=7; range 220 - 135 g) respectively.

On one occasion when mother and young had been caught in the same trap, the young attempted to enter the pouch but was refused. The mother adopted an arched-back stance (described earlier) but held her pouch closed. When the pouch of the mother was examined, three 2 day old pouch young were found. The post-emergent young was estimated to be about 70 days old and if the gestation period of *Perameles gunnii* is assumed to be about 12.5 days (Lyne 1974), these pouch young were probably conceived when the emergent young were about 56 days old (just weaned).

The live-trapping of both mother and young in the same trap indicates that juveniles continue to be closely associated with, and dependent on, their mother for some time after weaning. During one occasion, two juvenile females (about 57 days old) were trapped with their mother. Upon unassisted emergence from the handling bag, the mother moved quickly into some tussock grass about 1.5 m to the north. One young followed her closely, while the other headed west but stopped about 2 m from her mother and made a soft squeak that was repeated five times at about one second intervals. The mother backtracked about half a metre and made a single low 'honk' that attracted the young to her and reunited the trio. The mother then slowly moved east out of cover at a walking pace and jumped onto the wire mesh of a mattress base. Again one young followed closely and climbed onto the base while the other (the one that was initially lost) went under the wire mesh of the base. Although this young could hear and see her mother, she remained out of contact. Exten-

Table 3. The development of pouch young of eastern barred bandicoot, *Perameles gunnii* in Victoria. Descriptions were based on observations of 27 young in 13 litters in both the free-ranging population at Hamilton and captive population at Gellibrand Hill Park, Victoria.



sive vocalisations and searching for a break in the mesh by both mother and young were perceived until, probably by chance, the mother and young jumped off the base and the trio was reunited a second time. The mother then led the young northwards into a pile of Monterey Cypress *Cupressus macrocarpa* limbs where they were last seen.

Description of sub-adult

Sub-adults appear to be proportionally similar to, though smaller than, adult *P. gunnii* (Table 2). The youngest female to successfully mate was about three months old although the mean age of females at first successful mating was 3.5 months (109 days; n=9). The onset of male sexual maturity is more difficult to determine using morphometric data. The growth of the scrotum appears to plateau when *P. gunnii* are about 5 - 6 months (about 640 g body weight). Therefore, independent *P. gunnii* reach sexual maturity between 3 and 6 months. The period when *P. gunnii* are subadult can be morphometrically defined as when head length is greater than 74 mm and body weight is greater than 400 g but equal to or less than 640 g.

Discussion

During this study, *P. gunnii* were grouped into three age classes: 0 - 3 months (juvenile), 3 - 6 months (subadult) and greater than 6 months (adult). These age classes also represent developmental stages. The juvenile stage is when young are dependent on their mother for nutrition and shelter; the sub-adult stage represents when young are independent, becoming sexually mature and developing to full adult size, and; the adult stage is when *P. gunnii* are fully mature and independently established in their own home range. Dufty (1994 *b*) utilised these three age classes and further subdivided the adult group into three-month intervals to facilitate more intensive demographic analysis. Lyne (1964), Brown (1989) and Minta *et al.* (1990) classified the population on the basis of body weight into juvenile and adult. Dufty (1991*a*) utilised three age classes: less than 150 g, between 150 and 500 g, and greater than 500 g to designate juvenile, sub-adult and adult groups respectively. During this study, head length was favoured over body weight and foot length due to the greater consistency of measurement, the slow growth of body weight and foot length early in development, and the ease of head length measurement for *P. gunnii* of all ages. Lyne (1964) and Heinsohn (1966) also believed head length to be the most suitable measurement for ageing juvenile bandicoots. Head length measurements were accurate for age estimation of juveniles and subadults. However, the growth of *P. gunnii* slowed after six months while variations due to individual and seasonal differences increased. Therefore, age estimation using head length and body weight may be considered unreliable for individuals that are nine months or older. This may be of little concern during close demographic monitoring of *P. gunnii* due to their high trappability (Minta *et al.* 1990; Dufty 1994 *b*) and the likelihood that most individuals in the population will be encountered as juveniles, sub-adults or young adults.

The description of *P. gunnii* pouch young during this study was similar to descriptions given by Heinsohn (1966) and Lyne (1964; 1951). The head length for neonate *P. gunnii* (5.8 mm, this study; 5.3 mm, Heinsohn 1966) was similar to the head length of newborn *P. nasuta* (6.3 mm, Lyne 1964). Newborn *Isoodon* sp. may be similar in size (based on head length) to newborn *Perameles* sp. Mackerras and Smith (1960) determined a mean head length of 4.5 mm for *I. macrourus*, and Heinsohn (1966) determined that the head length of *I. obesulus* neonates from three litters were 5.8 mm, 6.6 mm and 6.0 mm.

Young remained in the pouch for about 46 days and after emergence were able to re-enter the pouch until about day 53. Similarly, Heinsohn (1966) believed the period of emergence occurred when young were aged between 48 and 53 days. A large range in body weights was observed for emergent young during both this study (mean = 81.4 g, range: 140-42.5 g) and Heinsohn's (1966) study (mean = 82.5 g, 143-61 g). The high variation in pouch young body weight may directly reflect the amount, and nutritional value, of milk produced by the mother. Stoddart and Braithwaite (1979) and Claridge *et al.* (1991) suggest that males frequently occupy optimal habitat and that few food resources and little shelter may be present in suboptimal areas (Dufty 1994 *c*). Female *P. gunnii* that inhabit suboptimal areas may need to forage longer, spend more time avoiding predators and conspecifics, and use more energy keeping warm than females in optimal habitat. Hence, the size of pouch young and timing of their emergence may be dependent on the mother's position in the dominance hierarchy in addition to seasonal and climatic factors. Heinsohn (1966) maintained a mother and pouch young alone in a captive enclosure (presumably with adequate food and shelter) and observed that the litter remained in the pouch until day 55 and periodically emerged and re-entered the pouch until day 58, considerably longer than was observed for free-ranging *P. gunnii* in Tasmania and Victoria.

Heinsohn (1966) believed that young were kept in a nest for several days after emergence. The youngest and oldest post-emergent dependent juveniles were 57 days and 86 days old and if a period of nest-life was present during this study, it probably occurred between day 46 (emergence) and day 57. Young appeared to be dependent on their mother until they are about 3 months old, after which female and male *P. gunnii* appear to become more independent and sexually active. Sexual maturity appears to occur at about 3.5 and 5 months for females and males respectively, although Heinsohn (1966) believed that females and males reached sexual maturity at 3 and 4 - 5 months respectively.

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Activity and Stratification of Microchiropteran Bat Communities in Thinned, Unthinned and Old Lowland Regrowth Forest, East Gippsland

A. S. Kutt[1]

Abstract

The results of a survey of bat species using ultrasonic detectors in thinned, unthinned and old regrowth forest in East Gippsland were examined to determine if structural differences of these forest types influenced the type of bat communities present within them.

There were no statistically significant differences in individual species or total relative activity between forest types, although a higher level of activity was recorded in unthinned forest, possibly due to a more complex vertical structure. Species recorded were divided into community guilds according to flight and foraging behaviour. No significant differences were recorded in relative guild activity between forest types, though some simple trends were observed in relation to species flight characteristics, vertical foraging position and structure of the forest type.

Introduction

The availability of roost sites, foraging resources and individual species mobility all influence microchiropteran bat distribution and activity within a forest (Lunney *et al.* 1985; Taylor *et al.* 1987; Parnaby and Cherry 1992). In this case, it may be predicted that alterations to the number of potential roost sites, the vertical structure of a forest and an individual bat species' ability to travel from roost sites to foraging sites may affect bat community composition and level of activity in a forest.

Recent studies of roosting and foraging behaviour, and movement patterns of microchiropteran bat species (such as those listed in Table 1) have concluded the following.

(i) Many forest bat species will forage 1-2 km from roost sites, but may move up to 6-7 km during an evenings foraging (Parnaby and Cherry 1992). Movements of 5 km for *Chalinolobus morio* and *Nyctophilus geoffroyi* (Lunney *et al.* 1985; Taylor and Savva 1988) and of 7-12 km for *N. geoffroyi* and *Falsistrellus tasmaniensis* (L. Lumsden, *pers.comm.*; Parnaby and Cherry 1992) have been measured.

(ii) Many forest bat species have a tendency to roost in large, old hollow trees with diameters greater than 80 cm (Lunney *et al.* 1985; Lunney *et al.* 1988; Taylor and Savva 1988) and often choose roosts with openings and cavities with one dimension only slightly larger than the bat (Tidemann and Flavel 1987; Taylor and Savva 1988). Features such as fissures, burnt boles, hollows, bark and residual (down) wood are often utilised (Taylor and Savva 1988).

(iii) Relationships also exist between wing morphology, echolocation call structure and habitat use (Aldridge and Rautenbach 1987). Variations in wing morphology result in differences in flight speed and manoeuvrability (Dwyer 1965). Because of this, microchiropteran bat species are vertically distributed in the forest profile, according to their foraging and flight behaviour (Taylor *et al.* 1987). Both Crome and Richards (1988) and McKenzie and Rolfe (1986) demonstrated that bats can be grouped into foraging guilds that specialise in different vegetation and structural areas within a forest.

This study examined the differences in activity and species composition of microchiropteran bat communities between forest types with different disturbance histories. Structural changes to the vegetation profile, (e.g. a decrease in large potentially hollow-bearing trees, an open canopy structure, thick shrub layer, increase in young regenerating trees) associated with thinned, unthinned and old regrowth forest were expected to influence the presence of some bat species in the forest.

Study Sites and Methods

The study sites were located in East Gippsland, Victoria, in State Forest 50 km east of the township of Orbost. Five sites were examined: Dyers Creek in the Cabbage Tree Forest Block; Towser Creek in the Jirrah Forest Block; Stare Track in the Purgagoolah Forest Block; Hippo Track and Patrol Track both in the West Bemm Forest Block (Fig. 1). All these forests are managed by the Victorian Department of Conservation and Natural Resources. Much of the area has been selectively logged or clear-

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felled over the past 30-40 years, and the vegetation is dominated by eucalypt regrowth (LCC 1985). The vegetation of all five sites has been described as Lowland Forest (Woodgate *et al.* 1994).

Three types of forest stand were selected for examination: 25-35 year old regrowth coupes thinned between 1988-1992, 25-35 year old unthinned regrowth coupes and forest coupes that have only been selectively logged in the past (old regrowth). In total there were 11 sites in thinned regrowth (two in each study area, except Stare Track which contained three), 10 in unthinned regrowth (two in each study area) and 5 in old regrowth forest (two each at Hippo Track and Towser Creek and one at Dyers Creek). Even numbers of sites for all forest types could not be achieved due to the lack of old forest coupes adjacent to the thinned and unthinned sites in the study area. Each site represents a separate coupe.

Relative bat activity and species presence for each site was surveyed using ultrasonic bat detectors. Each site was monitored twice for 40 minutes over two different nights, the calls being recorded on cassette tape for later analysis. Bat detectors and recorders were always placed in an area that seemed to constitute a clear flight path. Two different sites were always recorded simultaneously, so relative activity could be quantitatively assessed for different sites. Various combinations of simultaneously recorded sites

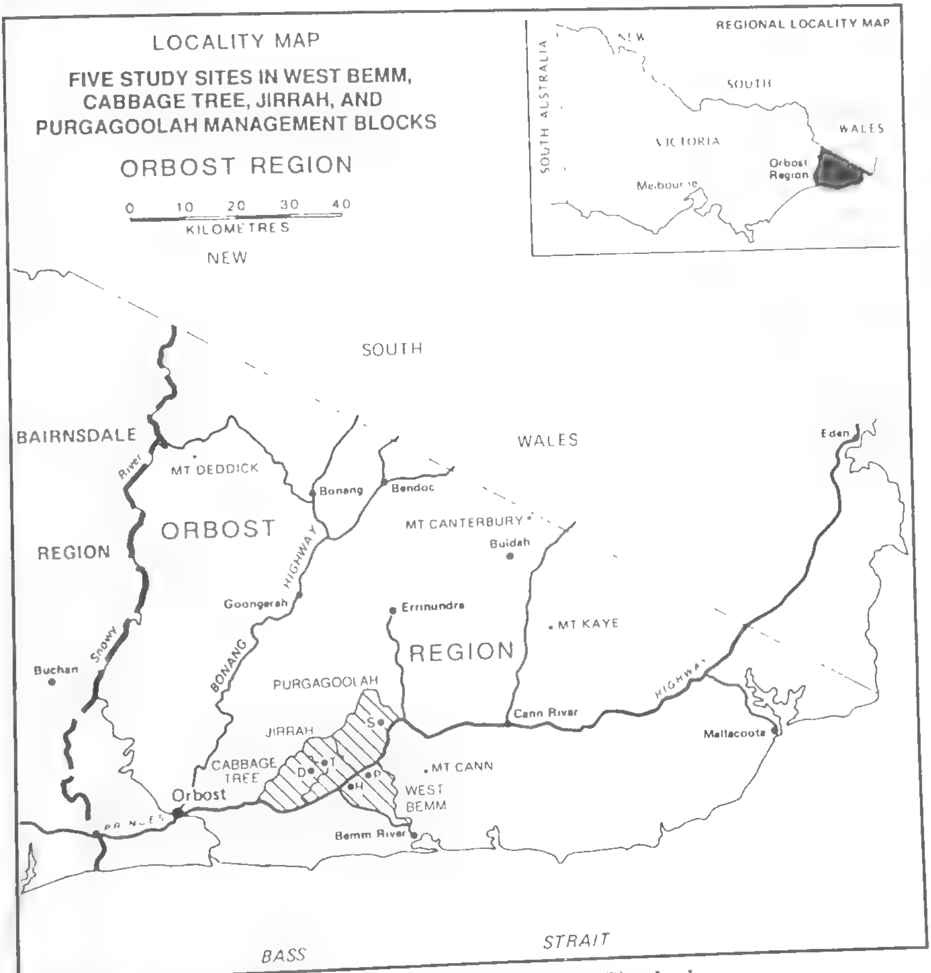

Fig. 1 Location of study sites in forest management blocks, East Gippsland.
H - Hippo Track, **P** - Patrol Track, **D** - Dyers Creek, **T** - Towser Creek, **S** - Stare Track.

were used. All recording was conducted between dusk and 90 minutes after dusk, a period when bat activity is perceived to be greatest. All field work was conducted between 7 January 1993 and 14 of March 1993 and no recording was conducted on nights perceived to be sub-optimal for bat activity (e.g. cold or wet nights, with temperatures <15°).

The number of passes (a single clear echolocation sequence recorded on the detector) for each species was counted for each 40 minute tape. From this, the relative activity levels for each species in each treatment were estimated. Relative activity was simply the number of passes recorded for a species at a treatment site as a proportion of the total number of bat passes recorded for a single simultaneous monitoring session. These measures were then used to calculate the mean relative activity for each species in each of the three forest types.

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Species level identification was possible using local reference sequences collected by the author, and pre-recorded sequences on the ANABAT 1.1 analysis package. ANABAT II bat detectors were used for the field recordings and the ANABAT II Zero Crossings Analysis Interface Module was used for the call interpretation and species identification (David Titley Electronics, Ballina, New South Wales). The *Nyctophilus* species group and two species *Vespadelus vulturnus* and *V. regulus* were each treated as a single echolocatory complex, as they were deemed by the author to be too similar in pattern and frequency to differentiate confidently.

The bat species recorded in this survey were grouped into guilds according to flight characteristics and foraging behaviour as assessed from previous surveys of bat populations (Dwyer 1965; Fenton 1972; McKenzie and Rolfe 1986; Taylor *et. al* 1987). Criteria and groupings are listed in Table 1. Statistical analysis used a non-parametric method, the Kruskal-Wallis analysis of variance by ranks (Siegel and Castellan 1988). Nomenclature throughout this report follows Richards *et al.* (1993).

The structural differences in vegetation between the three sites are summarised in Table 2 and can be described as follows. Thinned forest is characterised by an overstorey of many, small, thin trees with a poorly developed canopy and containing very few trees with a diameter greater than 50 cm (and hence few well developed or large hollows), a low, open and rich shrub layer and almost no other trees other than Eucalyptus species in the sub-canopy.

In comparison, the unthinned regrowth forest is characterised by an overstorey containing more trees with diameters greater than 50 cm (and hence more trees with hollows), a shrub layer that is of a similar height to the thinned forest, but containing fewer species with greater cover and a rich middle stratum of 16 non-Eucalyptus species greater than 6 m in height.

Lastly old forest is characterised by a well developed mixed species Eucalyptus overstorey containing fewer but larger trees, including many greater than 50 cm in diameter (and hence a larger number of hollows), an understorey of taller thicker shrubs with a very high species richness and a very low number of non-eucalypt species greater than 6 m in height.

Results

A total of 10 species and one species group were recorded for all treatment sites using ultrasonic bat detectors. The species recorded at each site and their relative abundance is given in Table 3.

There were no statistically significant differences in total level of activity of all bat species recorded across treatments, though total activity was highest in unthinned sites and lowest in old forest stands (Table 4).

Examination of the differences between the guilds also indicated no statistically significant differences between the treatments. However, some general trends between forest types were revealed. Thinned stands had a higher proportion of species in guilds 1 (high speed, low manoeuvrability, above canopy) and 3 (low speed and manoeuvrability below and beside canopy), unthinned a higher proportion of species in guilds 2 (high speed and low manoeuvrability at and beside canopy) and 5 (low speed and high manoeuvrability inside canopy) and old stands a higher proportion of species in guild 4 (high speed and manoeuvrability below and beside canopy) (Table 4).

Table 1. Guild classification for bat species recorded in thinned, unthinned and old forest treatment sites, using foraging and flight characteristics to group species (after Dwyer 1965; Fenton 1972; McKenzie and Rolfe 1986; Taylor *et al.* 1987).

Guild	Species	Foraging area and behaviour	Speed	Manoeuvrability
1	*Tadarida australis* *Mormopterus* spp.	Fast aerial feeders, foraging high above the canopy or in large gaps beside the canopy	High	Low
2	*Miniopterus schreibersii* *Chalinolobus gouldi*	Fast aerial feeders foraging close to and above canopy, or in gaps beside the canopy	Medium-High	Low
3	*Scotorepens orion* *Falsistrellus tasmaniensis* *Vespadelus darlingtoni*	Medium to slow aerial feeders foraging below, inside and beside the canopy and sub canopy	Medium-Low	Medium-Low
4	*Chalinolobus morio* *Vespadelus vulturnus* *Vespadelus regulus*	Medium to fast aerial feeders foraging below, inside and beside the canopy and sub canopy Medium-High Medium-High	Medium-High	Medium-High
5	*Nyctophilus* spp.	Gleaners foraging inside the canopy, sub canopy and shrublayer	Low	High

Table 2. Overstorey and understorey structural characteristics of thinned and unthinned regrowth and old forest in East Gippsland (adapted from Kutt *et al.* 1993).

		Treatment	
Structural characteristics	**Thinned**	**Unthinned**	**Old**
Stocking of all eucalypts (per ha)	1,491	1,406	1,082
Stocking of eucalypts diameter > 50 cm (per ha)	21	24	52
Average diameter of all eucalypts (cm)	21.0	25	28
Number of stags diameter > 50 cm (per ha)	7.0	12.0	4
Average cover of understorey shrubs (%)	0.3	0.6	1.3
Average height of understorey shrubs (m)	0.7	0.7	1.5
Richness of non-eucalypt species > 6 m	3	16	3
Richness of understorey shrub species < 6 m	31	25	35

Discussion

This survey indicated that there was no statistically significant differences between bat activity in thinned, unthinned and old regrowth forest sites. This may suggest that the bat species recorded in this study may not forage preferentially in any of the forest types examined, though no conclusions can be drawn on the specific type of activity (e.g. foraging or flying through, roosting) undertaken by each species in the study sites. As the species richness for each forest type was almost equal, it can be concluded that these bat species utilised, or were at least present, in thinned, unthinned and old regrowth forest at some stage. Other studies have also recorded bats active within logged and plantation forests, but generally foraging and roosting in areas of old growth forest nearby (O'Neill and Taylor 1986; Parnaby and Cherry 1992).

The highest total bat activity was recorded in unthinned regrowth forest. This may be a function of the structural complexity of the unthinned forest (see table 3) compared to thinned and old forest sites. Unthinned forest may provide a greater variety of vertical foraging niches (and possibly prey items). Tidemann and Flavel (1987) have also suggested that bats may recolonise regrowth forest before other hollow requiring species, due to their ability to roost in small hollows and fissures and under exfoliating bark.

Though there may be an expectation of higher relative bat activity in sites where there are potentially more roost hollows, the lower proportion of activity recorded in old regrowth may reflect a pattern of bats roosting in these sites but actively foraging elsewhere. Previous studies have indicated that the distribution of bats in an area is not a reflection of roost site availability (Taylor and O'Neill 1986; Lunney *et al.* 1988; Parnaby and Cherry 1992). The presence of *Miniopterus schreibersii,* (a cave and aqueduct roosting species), in each forest type may also reflect that foraging area and roosting sites do not necessarily correspond. For this species these forests may be important as foraging sites.

No information on roosting sites or origin of bat species foraging in the forest stands was collected, however two general hypotheses from the results of the present study could be postulated. Firstly, the proximity and ample number of hollow bearing trees in all sites (from riparian growth, old forest areas, stags and overwood), may mean that roosts are not a limiting resource in these areas. Secondly as was indicated above, bats

Table 3. Average proportion of relative bat activity for each species, expressed as a percentage of the total level of activity recorded in thinned, unthinned and old forest types.

	Treatment		
Species	**Thinned (n=22)**	**Unthinned (n=20)**	**Old (n=10)**
Vespadelus vulturnus, Vespadelus regulus	0.31	0.33	0.42
Chalinolobus morio	0.15	0.15	0.22
Vespadelus darlingtoni	0.19	0.06	0.09
Miniopterus schreibersii	0.04	0.02	0.03
Nyctophilus spp.	0.19	0.26	0.16
Scotorepens orion	0.06	0.09	0.06
Chalinolobus gouldi	0.02	0.07	0.01
Mormopterus spp.	0.01	0.02	0.01
Falsistrellus tasmaniensis	0.006	0.004	0
Tadarida australis	0.03	0.007	0.01

Table 4. Mean proportion (and standard error) of bat guild activity in thinned, unthinned and old forest sites. Bold type indicates treatment with highest proportion for that particular guild.
A = above canopy, C = close to canopy, I = inside canopy,
B = below and beside canopy, LS = low speed, HS = high speed,
LM = low manoeuvrability, HM = high manoeuvrability.

	Treatment		
Guild	**Thinned (mean ± s.e.)**	**Unthinned (mean ± s.e.)**	**Old (mean ± s.e.)**
Guild 1 (A-HS-LM)	**0.02 ± 0.003**	0.01 ± 0.004	0.01 ± 0.007
Guild 2 (C-HS-LM)	0.03 ± 0.017	**0.05 ± 0.019**	0.02 ± 0.005
Guild 3 (B-LS-LM)	**0.12 ± 0.029**	0.09 ± 0.033	0.07 ± 0.017
Guild 4 (B-HS-HM)	0.22 ± 0.048	0.26 ± 0.048	**0.30 ± 0.057**
Guild 5 (I-LS-HM)	0.10 ± 0.012	**0.14 ± 0.031**	0.07 ± 0.047
Totals	0.48 ± 0.187	**0.55 ± 0.171**	0.46 ± 0.118

can travel large distances from roost to foraging site so the mosaic pattern and size of the regrowth coupes, old forest and thinned forest (coupes were only 10-40 ha in size) is not restrictive to bat movement from roost to foraging site.

Though there were no statistically significant differences in activity of bats in each guild at each treatment site, a few general trends emerged.

Guild 1 (relatively higher proportion in thinned forest). These fast flying species with low manoeuvrability may forage at lower levels and in the gaps created in thinned forest due to the more open, accessible structure. Crome and Richards (1988) also indicated fast aerial feeders preferentially forage in gaps and areas lacking a dense canopy.

Guild 2 (relatively higher proportion in unthinned regrowth forest). These bats were recorded in very low numbers in all sites. Dwyer (1965) and Taylor *et al.* (1986) note these species tend to forage beside stands or in open woodlands and farmland, and therefore may not be commonly recorded in any of these forest sites. These species are more likely to be recorded along tracks and major roads.

Guild 3 (relatively higher proportion in thinned regrowth forest). These are larger bats with low manoeuvrability and medium speed, that forage just below the canopy and in the sub canopy. Like the faster aerial feeders in guild 1, these species may prefer to forage in thinned stands, where there are more gaps and open spaces.

Guild 4 (relatively higher proportion in old regrowth forest). These medium fast and highly manoeuvrable aerial feeders, forage close to the sub-canopy and shrublayer (Taylor *et al.* 1986). The higher proportion of these species in old regrowth forest and unthinned regrowth forest may reflect an ability or preference to forage in a structurally more complex vegetation profile (e.g. rich and dense understorey and shrub layers).

Guild 5 (relatively higher proportion in unthinned regrowth forest). As these slow flying, highly manoeuvrable species glean invertebrates from inside foliage and shrub layers (Taylor *et al.* 1986), the more complex, thicker vegetation of the unthinned sites may be preferred foraging sites.

There are a number of limitations in this survey that need clearer discussion.

Firstly, monitoring of bat activity only provides an estimation of relative activity using a count of the number of 'passes' (a single distinct echolocatory sequence) during a set time period. The use of simultaneous monitoring to provide comparison of relative activity between sites overcomes this problem to a degree, but still lacks the resolution of direct counting of individual bat species and numbers at a site. Because of this, the results of this study should be taken as indicative of likely patterns of bat activity in each forest type.

Secondly, there is no information on the origin of the bats recorded in each treatment (i.e. location of roost site, type and size of tree, distance travelled to foraging area). Therefore the effect of the forest type on foraging activity and forest use for different species could only be inferred from available structural information.

Thirdly, bat detectors only have a limited range of recording and this can be influenced to some extent by the height and closure of the forest canopy. Therefore, it is possible that in forest types with a more open canopy structure (e.g. thinned regrowth) the detectors may be more likely to record above canopy foragers than those recording in dense unthinned regrowth. These issues are discussed in Crome and Richards (1988) and Kutt (1993).

In conclusion, this study suggests that there is no difference in relative activity and species composition between thinned, unthinned and old regrowth forest coupes of small size. There is some variation in preference of some species or guilds for particular foraging areas and this may be dependent on the vertical structure of that forest, the resources available at that site and the flight and foraging characteristics of the bat species. More detailed surveys are required to determine the type of activity of these bat species in thinned and unthinned regrowth forest, including the extent of foraging and whether they actually roost in these areas or originate from sites containing old, hollow-bearing trees (e.g. old regrowth, riparian gullies).

Clearly, longer term monitoring and more detailed surveys of these sites is necessary to examine how bat populations respond to changes in the forest over time, particularly if extensive, continuous areas of forest are thinned or remain as even-aged regrowth, and further intensive management is applied to the stand in an effort to enhance wood production potential. Intensively managed native regrowth forest is likely to become an increasingly prominent element of the forest in south-eastern Australia. The implications of this management compared to untended regrowth deserve to be examined and carefully considered in the development of conservation strategies in native forest.

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Factors Contributing to a Fish Kill in Broken Creek

Lachlan McKinnon[1] and Nik Shepheard[1]

Introduction

Seasonal flooding is an important factor for the successful spawning and recruitment of many native freshwater fish species in the Murray-Darling Basin (Lake 1967; Mackay 1973; Rowland 1989). The regulation of rivers which involves the impoundment of water during the winter and spring months and subsequent release throughout summer and autumn for irrigation, stock and domestic purposes, is often cited as one of the major causes of the decline of many of our native fish species (Reynolds 1976; Cadwallader 1978, 1986; Pollard *et al.* 1990).

During a large-scale flood event in October 1993 in the Broken River drainage basin, a fish kill occurred in the Broken Creek downstream of Nathalia in northern Victoria (Fig. 1). Murray Cod *Maccullochella peelii peelii*, appeared to be the most adversely affected native species, although Freshwater Catfish *Tandanus tandanus*, Golden Perch *Macquaria ambigua* and the introduced Carp *Cyprinus carpio* and Redfin *Perca fluviatilis* were also killed. Large numbers of shrimp, *Macrobrachium* and *Paratya* sp. and Yabbies *Cherax destructor*, also died during the flood event.

Although not uncommon, fish kills are sporadic events and can result from both anthropogenic causes, such as point-source pollution, and from 'natural' causes, such as disease epidemics and acute water quality changes (Harbison 1984; Trim and Marcus 1990). Major changes in water quality often occur with flooding (Cullen *et al.* 1978; Beer *et al.* 1981; Hart *et al.* 1987, 1988) and flood mitigation works have been implicated in causing fish kills through rapid de-oxygenation of water after flooding (Richardson 1981). Large-scale fish kills were also reported from the first releases of water from Hume Weir (Cadwallader 1978). Murray Cod have been reported in fish kills on other occasions in Victoria: the Ovens River downstream of Wangaratta (Anderson, undated) and in the Broken Creek at Nathalia in 1936 (J. O'Hare *pers. comm.*). However, the causes of these kills were unknown. Fish kills involving large numbers of Redfin have also been reported from Victoria (Anon. 1984; Langdon 1984) and in several cases were attributed to epizootic haematopoietic necrosis virus (EHN) (Langdon 1986; Langdon *et al.* 1986; Langdon and Humphrey 1987). Fish kills attributed to hypoxia have been reported in the Broken and Goulburn River Basins on previous occasions (Anderson and McNamara 1984; Anon. 1986) but the introduced Carp and Redfin were the species most affected and no native species were reported on these occasions. A fish kill involving Murray Cod and Carp occurred in Menindee Lakes and was attributed to the lowering of the water level in the lake (Gregory 1994).

This paper reports on a fish kill which occurred in the Broken Creek in 1993. It is proposed that this kill was due to hypoxic water conditions caused by the runoff from exceptionally large-scale flooding in an area where native riparian and floodplain vegetation has been largely replaced by introduced pasture and crop species.

Site Description

Broken Creek is a relatively small tributary of the Murray River, extending some 200 km from its effluence from the Broken River, downstream of Benalla, to its junction with the Murray River near Barmah. It is a lowland stream, fairly typical of the Murray-Darling Basin with a low gradient, relatively low flow, predominantly clay and silt substrate and with relatively high turbidity. Broken Creek is used for both water supply and drainage disposal for irrigation and urban use. A total of nine weirs in various stages of repair are present on Broken Creek, most of which are downstream of Nathalia. As a result fish passage is limited to periods of high flow when weirs are overtopped or by-passed by floodwater.

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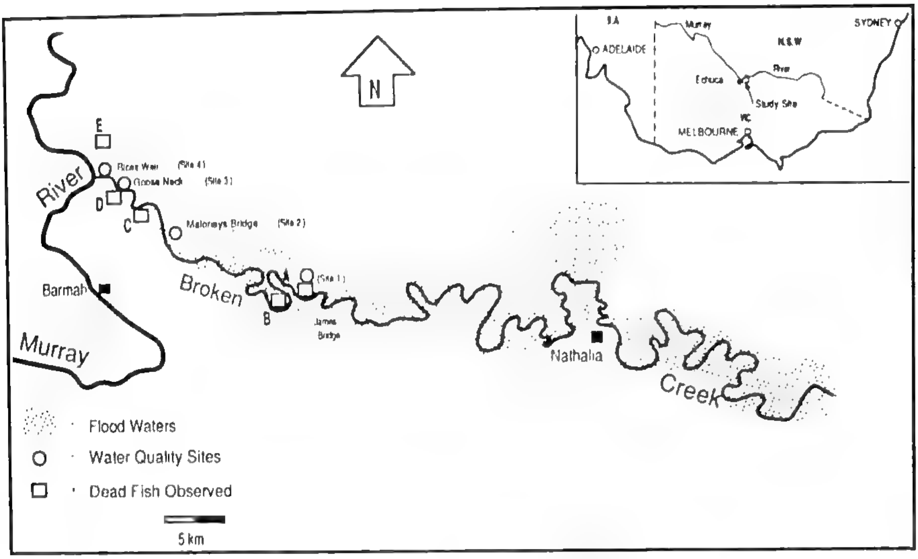

Fig. 1. Map of study area indicating water quality and fish sampling sites.

Much of the riparian vegetation, particularly along the lower reaches of Broken Creek, has been removed for grazing and cropping both of which often occur right to the water's edge. Consequently, an important aspect of fish habitat in Broken Creek has been adversely affected but despite the apparently high degree of modification and disturbance, a relatively good population of Murray Cod exists in the creek.

Methods

The first reports of dead fish in the Broken Creek were made on October 19. *In situ* measurements of dissolved oxygen and temperature were subsequently made using a YSI Model 57 Dissolved Oxygen Meter and *in situ* pH measurements were made using an Orion 250A pH meter. Water quality measurements were repeated over the following three weeks. Water samples were collected at several sites on two separate occasions and preserved in eleven washed plastic bottles for later analysis of pesticide residues by the Rural Water Corporation Melbourne, using standard methods (RWC 1988). Total length (TL) measurements of dead Murray Cod were taken to the nearest 5 mm and freshly dead fish were weighed to the nearest 2g. Fish entangled amongst in-stream snags were retrieved for measurement using hand-held grappling hooks.

Results

Dead Murray Cod were first reported on October 19 and again on October 31 (1993) in the section of Broken Creek from James Bridge to its junction with the Murray River (Fig. 1). The fish observed on the latter occasion had been dead for some time and it is presumed they had died at the same time as the initial report but had only become visible once the water level in the Broken Creek had receded. Dead fish were observed on the banks of the creek and partly submerged amongst inundated rye-grass (*Lolium* spp.). The fish species and numbers observed are listed in Table 1. Murray Cod were the most numerous (91%) of all the native fish species observed in the fish kill; a total of 41 Murray Cod were found dead and the majority (26) of these were found at site B in a 150m stretch of creek bank (Fig. 1). The length-frequency distribution of the Murray Cod measured is shown in Fig. 2. The length range of Murray Cod measured was 255 to 1260 mm TL and included several mature female fish (Fig. 3).

Water quality measurements were made on October 20 and 26 and November 4 and 5 (1993) and results are presented in Table 2.

Table 1. List of fish and macrocrustacean species observed during the fish kill.

Common Name	Scientific Name	Site	Nos.
Native Species			
Murray Cod	*Maccullochella peelii peelii*	A	8
		B	26
		C	4
		D	2
		E	1
Golden Perch	*Macquaria ambigua*	A	2
Freshwater Catfish	*Tandanus tandanus*	A	2
Shrimp	*Macrobrachium* australiense	All Sites	>1000
	Paratya australiensis/ Caridina mccullochi	All Sites	>1000
Yabby	*Cherax destructor*	All Sites	>1000
Introduced Species			
Carp	*Cyprinus carpio*	A	2
Redfin	*Perca fluviatilis*	A&B	ca.200

Fig. 3. Dead female Murray Cod prior to spawning. Note expelled eggs.

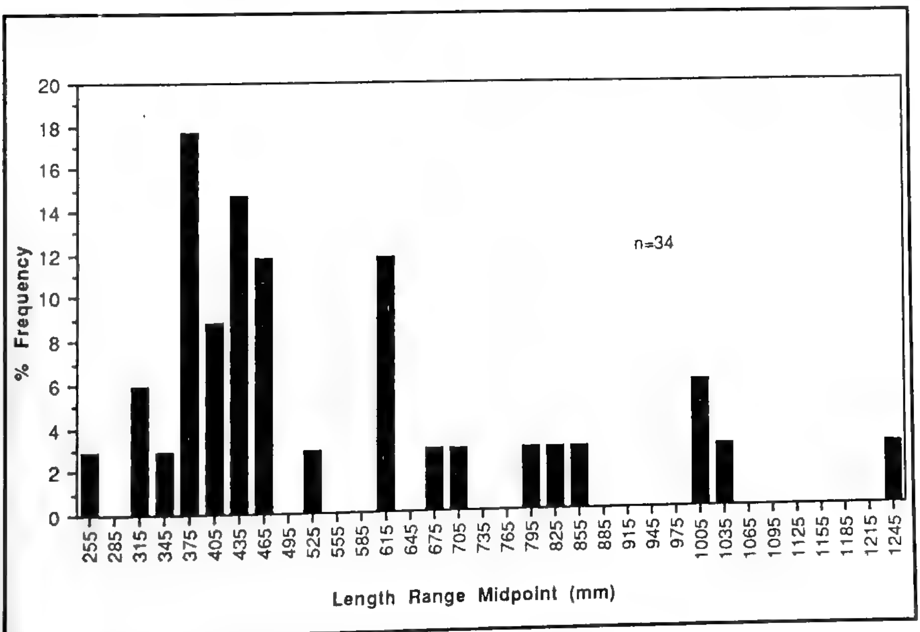

Fig. 2. Length-frequency distribution for Murray Cod from Broken Creek fish kill, 1993.

At the time of the fish kill, dissolved oxygen was 0.1 mg/l throughout the water column (dissolved oxygen levels of around 3.0 mg/l and above would be considered as favourable). These low oxygen levels persisted for several days although they slowly improved with time and with distance downstream. Dissolved oxygen levels remained at below 1.0 mg/l at all sites on October 26 but improved to more favourable levels (4.1mg/l) by November 4. Temperature ranged from 16.5° to 18.0° C over all sites with pH ranging from 6.7 to 7.3 (Table 2) and these variables were not considered to have contributed to the fish kill. No chlorinated pesticide residues were detected from water samples collected (Table 2) and so pesticides were not implicated in this fish kill. Of the water quality parameters measured, hypoxia appears to be the primary cause of the fish kill.

Discussion

Although the length-frequency distribution of Murray Cod killed during this event suggests that a large proportion of this species killed were immature (Gooley *et al. in prep.* and references therein), the presence of mature fish in pre-spawning condition would indicate that spawning and subsequent recruitment of Murray Cod in the lower section of Broken Creek in 1993 would have been reduced because of this kill. The length-frequency distribution of the Murray Cod population in Broken Creek suggests that the bulk of the population is made up of sub-adult fish but with a smaller but significant proportion of adult fish. Subsequent fish surveys conducted in the area where the fish kill occurred did not produce any Murray Cod. However, Golden Perch and Carp were recorded in relatively high numbers (Douglas 1993).

Golden Perch and Freshwater Catfish are known to be present in the lower reaches of Broken Creek but only a small number of these species appeared to be affected during the fish kill. This was not unexpected for Freshwater Catfish as the catfish population of Broken Creek appears to be relatively small. Golden Perch, however, appear to be common in the creek and thus may be expected to have been represented in greater numbers in the fish kill. Adult Golden Perch may exhibit an ability to actively avoid adverse conditions such as extreme hypoxia. Gehrke (1991) demonstrated the tendency for Golden Perch larvae to avoid oxygen-deficient water and this type of behaviour is common for other species (Moller and Scholz 1991). Murray Cod, however, may be more tenacious in their behaviour and may not vary movement patterns in spite of poor water quality. Although Redfin are relatively tolerant of hypoxia at most stages of their life-history (Doudoroff and Shumway 1970) this species would not be expected to survive extended exposure to the low dissolved oxygen levels experienced during the fish kill.

It is expected that few aerobic aquatic organisms would survive extended exposure to the hypoxic conditions observed during the fish kill, although few data on tolerance limits of many native species to hypoxia are presently available, Ryan (*unpubl. data*) found adult Golden Perch and Catfish survived beyond 40 min. exposure to extreme hypoxia (0-2% saturation or 0.0 - <0.5 mg/l at 19.0 - 22.0° C) and adults were more tolerant than juveniles. Favourable long-term levels of dissolved oxygen would be about 30% saturation. It is quite conceivable that Murray Cod would be equally tolerant. It is suggested, however, that fish kills caused by low oxygen levels, such as that observed in the Broken Creek, may occur only when hypoxia is persistent and fish are unable to escape to alternative habitat areas containing favourable levels of dissolved oxygen.

Table 2. Water quality parameters measured during and after the fish kill.

Site	Date	Dissolved Oxygen (mg/l)		Temperature (C)		pH	Max. Depth (m)
		Surface	Bottom	Surface	Bottom	Surface	
1	20/10/93	0.1	0.1	18	18	6.8	2.5
2	26/10/93	0.3	0.3	17	17	6.7	2.8
3	26/10/93	0.7	0.6	17	17	7	2.2
4	26/10/93	1.1	0.5	17.5	17	7.1	2.8
4	4/11/93	4.1	4.1	17	17	7.3	3.5
2	5/11/93	4.1	4.1	16.5	16.5	—	2.4

Chlorinated Pesticides (mg/l) not detected at surface, sites 1 and 2.

Large numbers of Yabbies *Cherax destructor* were also observed dead during the fish kill (Table 1). This suggests that conditions were extremely poor for an extended period of time in Broken Creek as studies of the tolerance of a number of *Cherax* species to hypoxia indicate that these species are relatively tolerant of hypoxic conditions (Barley 1983; Morrissy *et al.* 1984; Bezzobs 1988).

Due to the wide range of fish and crustacean species recorded in the fish kill, it is likely that the cause was environmental rather than pathological.

The fish kill occurred prior to, and during, the peak of the flood which in Broken Creek reached a flow of over 4,500 Ml/day at Katamatite in early October (Fig. 4). Floodwaters covered an area of approximately 90 km^2 in the Nathalia area, much of which is managed as pasture and crop land comprising mainly annual and Perennial Rye-grass *Lolium* spp. and clover *Trifolium* spp., the crop species wheat *Triticum aestivum*, barley *Hordeum vulgare* and oats *Avena sativa* and common introduced weed species (G. Akers, Department of Agriculture, *pers. comm.*). Many of these introduced plant species exhibit little tolerance to inundation and waterlogging, particularly for extended periods (Department of Agriculture *pers. comm.*), although there is little published information on the flood tolerance levels of these species currently available. It is suggested that oxygen depletion of the floodwater due to the aerobic microbial degradation of these flood-intolerant plant species caused the observed dissolved oxygen depletion and hypoxia in Broken Creek after these floodwaters were channelled downstream.

Spring flood events can provide benefits to native fish populations through the provision of spawning stimuli (Lake 1967; Mackay 1973) and production of zooplankton during the initial feeding phase of juvenile native fish (Geddes and Puckridge 1989; Rowland 1992). Extensive flow events are probably of greater benefit than smaller floods. However, large proportions of floodplain and riparian habitats in the Murray-Darling Basin have been altered significantly with the clearing of large tracts of native vegetation in these areas and their replacement, in many instances, with exotic crop and pasture species that are often intolerant of extended periods of flooding. Inundation of these species causes rapid de-oxygenation of the floodwater due to the increased biological oxygen demand associated with the microbial degradation of organic matter (Reddy and Chhonkar 1990), and consequently poses potential problems for fish and aquatic invertebrates (Welcomme 1979; Gehrke 1993). Under natural conditions, more often than is currently the case (e.g. Dexter *et al.* 1986), large scale flooding occurred in many floodplain areas

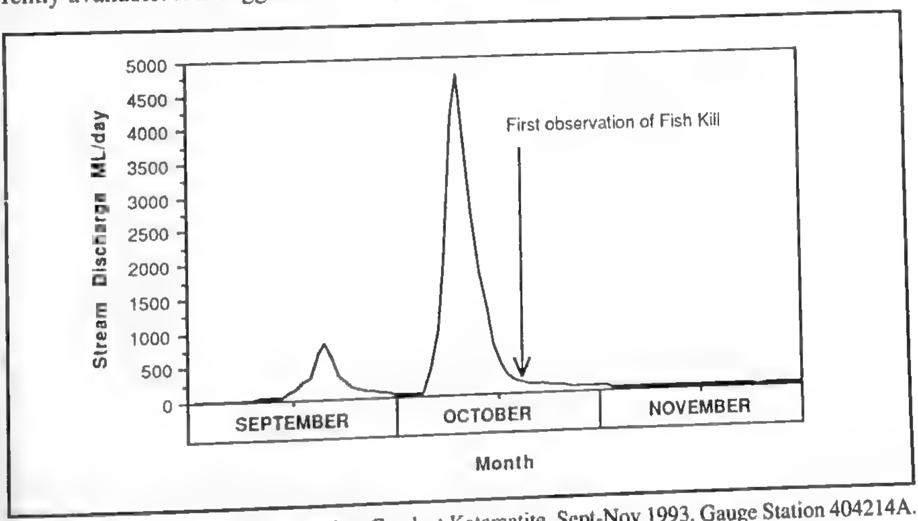

Fig. 4. Mean daily flows for the Broken Creek at Katamatite, Sept-Nov 1993. Gauge Station 404214A.

along the Murray River and its tributaries. However, under current land management regimes, extensive flooding of land cleared of native vegetation may not be desirable as this could exacerbate potential water quality problems associated with some flood events.

Departmental records and verified angler reports indicate that Broken Creek is one of only a few waterbodies in Victoria that support a naturally occurring riverine population of Freshwater Catfish (T. Raadik, Department of Conservation and Natural Resources, *pers. comm.*). Freshwater Catfish has recently been nominated for listing under the Victorian Flora and Fauna Guarantee Act (1988). The fact that this species was recorded in the fish kill places some concern over the future of this population in both this area and Victoria generally. This recent fish kill also adds to the concern regarding the status of the natural Murray Cod population of Broken Creek, particularly considering the heavy recreational angling pressure which resulted in the removal of over 1000 Murray Cod from the creek during the 1992 spawning season (D. Trickey, Department of Conservation and Natural Resources, *pers. comm.*).

Murray Cod is not listed nationally as a threatened species (Wager and Jackson 1993). It is, however, considered in Victoria as 'Vulnerable' (Koehn and Morison 1990) and is listed under the Victorian Flora and Fauna Guarantee Act (1988). An Action Statement outlining a range of management recommendations designed to enhance the conservation status of the species is expected to be released in 1994 (Reed *et al. in prep.*). Given the present conservation status of Murray Cod in Victoria, it is of concern that currently depleted Victorian stocks of Murray Cod are subject to fish kills (Cadwallader and Gooley 1984).

Revegetation with indigenous plant species and fencing of riparian zones and floodplain areas may be an option to reduce the incidence of fish kills. The manipulation of regulatory structures to provide water at desirable times of year to floodplain and riverine habitat areas is seen as a means of ameliorating the current unnatural flow regimes for the benefit of native fish (Jacobs 1989). Migration of several native fish species into forested floodplain areas and sexual maturation of these species have been associated with large scale seasonal flood events in Barmah Forest (McKinnon, *unpubl. data*). Thus, it appears that spring flood events provide benefits to native fish populations in relatively natural environments but on a large scale may actually be deleterious to their populations in areas where natural habitats have been attenuated.

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Occupancy of Peregrine Falcon Eyries near Melbourne during 1976-84 and 1992

W.B. Emison[1] and V.G. Hurley[2]

A study of Peregrine Falcons breeding at 21 eyries (20 on cliffs and one on a dam wall) near Melbourne between 1976 and 1984, showed a progressive decline in occupancy of the sites during the years in which data were collected (Emison *et al.* 1993). This occurred at the same time as high levels of eggshell thinning and contamination of eggs by organochlorine pesticides were known to exist within the population. However, during the same period the observation time spent by the scientists at eyrie sites was progressively reduced. In their paper, Emison *et al.* (1993) indicated that data on eyrie occupancy were not sufficient to determine whether the observed decline was due to pesticide contamination or to sampling bias. They suggested that a re-examination of the 20 cliff sites and the dam wall site near Melbourne during a future breeding season would be useful in determining whether the occupancy had actually dropped or, was commensurate with the levels found in the 1976-1984 study.

During the breeding season in 1992, all 21 nest sites were again visited and details of occupancy were recorded. Most of the sites were visited during the incubation period but there were not many follow-up visits during the chick-rearing period.

We found that 18 of the 21 sites (86%) were occupied by either one or two adult Peregrine Falcons. This is slightly higher than the mean occupancy (84%) for the nine years of 1976-1984. When this figure of 86% is included with those data which showed a negative correlation between the percentage of sites occupied and the years during which the data were collected (1976-1984), there is no longer a negative correlation. The previous data would have predicted a percentage occupancy of only about 59% (Fig. 1).

Therefore, we conclude that the decline in occupancy which was recorded between 1976 and 1984 was mainly because of sampling bias. However, it is possible that some contribution to the reversal of this decline can be attributed to reduced pesticide levels in the environment. The use of DDT in Australia peaked in the mid 1970's and then declined until it was finally banned for use on farms in 1987 (Olsen *et al.* 1992). By 1983, DDT residues in Peregrine eggs had begun to decline in Victoria (Olsen *et al.* 1992) and this may have been a factor in the recovery of the percentage occupancy of Peregrine eyries between 1984 and 1992.

Regardless of the reasons for the recovery

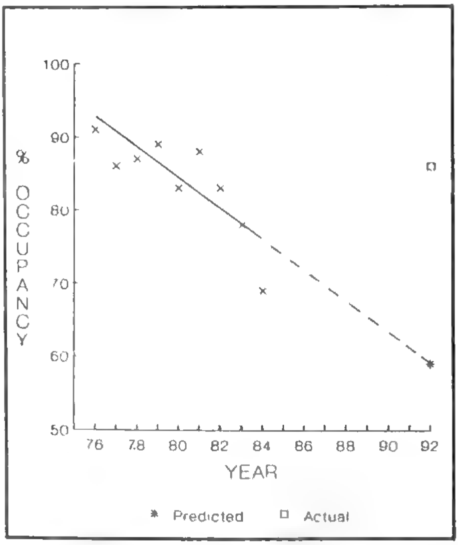

Fig. 1. Percentage of territories occupied by one or two Peregrine Falcons in relation to the years in which the data were collected. The solid part of the regression line indicates the negative correlation between the percentage of sites occupied and the data collection years of 1976 - 1984. If this negative correlation had continued during 1985 - 1991 (illustrated by broken line) when no data were collected, the predicted occupancy for 1992 from the regression (y = 93.86 - 2.02x) would be about 59%. However, the actual percentage occupancy was found to be 86%.

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in occupancy, most (86%) of the Peregrine eyries around Melbourne that were studied a decade or so ago are still occupied by one or two adult Peregrines. Of the three eyries found not to be occupied, two were probably vacated because of human disturbance and the other one probably because of natural causes.

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A Record of an Introduced Fish, the Oriental Weather Loach (*Misgurnus anguillicaudatus:* Family Cobitidae) from the River Murray Upstream of Corowa

Michael MacQueen[1]

The Oriental Weather Loach *Misgurnus anguillicaudatus* is a popular cold water aquarium fish in southern Australia. The species is typically found in still or slow-flowing waters with muddy bottoms (Burchmore *et al.* 1990). Weather Loach are tolerant of low oxygen levels, utilising atmospheric oxygen under extreme conditions (Burchmore *et al.* 1990).

Feral populations of the species are established at a number of locations throughout south-east Australia, having been recorded from the Yarra River near Melbourne, the Wingecarribee River south-west of Sydney and the Ginninderra Creek in the A.C.T. (Allen 1984; Burchmore *et al.* 1990; Lintermans *et al.* 1990). The species has previously been recorded from the River Murray at least as far upstream as the confluence of the Ovens and Murray rivers (G.P Closs *pers. comm.*). In this note I report the occurrence of the species in the bed of a dry depression on the floodplain of the River Murray between Corowa and Howlong (Grid reference 191591; 15,000, Lowersdale 8126-5, 1st ed.).

A single specimen of Weather Loach (length 61 mm) was discovered under a log while collecting Yabbies *Cherax destructor* on 24 July 1994. The fish was collected from a small depression located under the log. A further search yielded no additional specimens. At the time of collection, the depression contained no water although the surrounding soil was very damp. The depression in which the fish was found was located 95 m from the main channel of the River Murray, the nearest body of water. Another billabong containing water was located 105 m away in the opposite direction.

Upon finding the specimen I was able to identify it as the Oriental Weather Loach having read a newspaper article earlier this year. Formal identification was made by my Biology lecturer Dr G.P. Closs, La Trobe University - Wodonga who also retained the specimen in his private aquarium.

Water levels in the River Murray dropped following the cessation of summer irrigation flow in late April. Presumably the billabong in which this Weather Loach was found would have been isolated at some time during May. The exact time at which the depression dried out is unknown. The fish appeared to have suffered no obvious ill effect due to being out of water because it tried to wiggle away when first discovered and swam actively when placed in water.

To my knowledge, this record is the furthest upstream occurrence of Weather Loach in the River Murray. The origin of the specimen is not known, and could be derived from populations located further downstream or a recent aquarium release. It is not known whether there is a permanent population in the section of the Murray River. The finding of the fish in the absence of water is also significant, suggesting that this species

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may be able to tolerate a wider range of conditions compared with any other native or introduced fish currently recorded from the River Murray (Cadwallader and Backhouse 1983). It may be able to colonise some temporary wetland habitats from which other species are presently excluded due to periodic drying.

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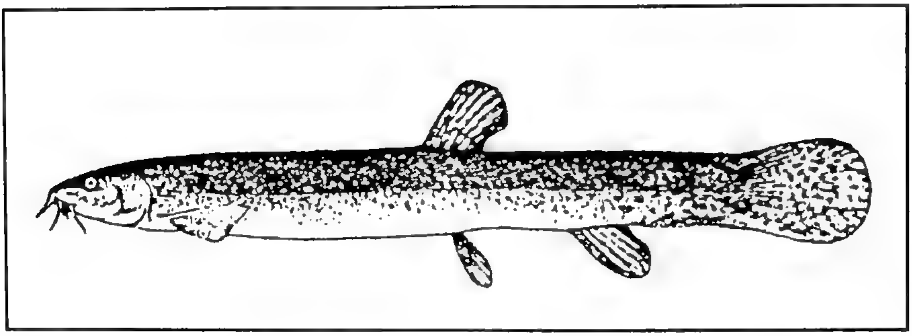

Weather Loach. Drawing courtesy of Department of Conservation and Natural Resources - Fisheries Branch.

From our Naturalist in Residence, Cecily Falkingham

Grey-headed Flying Fox

On Tuesday 11 January 1994, I observed a small group of Grey-headed Flying Foxes in my garden in Mitcham. They were feeding on the fruit of an Ornamental Cherry Plum *Prunus* sp. The time was 11 p.m.

I had visited the Botanic gardens in Melbourne on several occasions to view these beautiful animals so you can imagine my surprise, delight and excitement when I made the discovery.

During spring, summer and autumn I stroll around our garden with a small spotlight and miniature tape recorder. These nocturnal rambles have been carried out for many years and even the neighbours no longer worry when the sharp beam of the spotlight strays into their gardens late in the evenings.

Nocturnal insects, spiders and frogs so far being the main attractions with the nearby calls of Boobook Owls adding to the joy of my night walks.

Many people would be aware of the noise that Grey-headed Flying Foxes make whilst feeding not to mention the loud noise made by the large wings or flight membrane as they fly overhead.

I watched the bats each evening from approximately 11 p.m. until midnight or sometimes until 2 a.m. in the morning depending on how long I could tolerate being eaten alive by mosquitoes.

I found that they arrived within five minutes of their 11 pm 'rendez-vous' with the Cherry plums.

I soon discovered how good their eye-sight was when one evening I wore white sneakers (normally I wore dark clothing and shoes), they flew around and over, circling

Grey-headed Flying Fox. Photo by Lindy Lumsden.

my garden again and again and not until I hid myself did they settle down to their meal.

The group of seven animals divided their time between my garden and a garden nearby of over 3 ha. After gaining permission from the owners of the neighbours property I tried to observe what else they were feeding on.

I discovered that they had arrived one month ago on the larger property and had possibly been feeding on plums and loquat fruit, arriving at this property at 10.45 p.m. each evening.

By the time they had arrived at my garden all the fruit had been eaten at their first destination. Within three nights almost all the cherry plums were eaten in my garden.

Their food then consisted of nectar from *Eucalyptus globulus* sub species *bi-costata* and *E. cornuta*. Both of these Eucalypts growing on the neighbours property were heavy with flowers. Our last sighting of the bats was on 22 January 1994.

After making enquiries from Peter Menkhorst from the Arthur Rylah Institute, it would seem to be the first sighting from Mitcham where I live. It also seems to be the first recorded sighting of the bats feeding on *Eucalyptus cornuta*.

I phoned two other Naturalists who live in Mitcham, both of whom had no records of previous sightings in our area.

Conclusions:

- that the bats first food preference was a variety of plums and loquat fruit, and only when these were all gone did they turn their attention to the flowering Eucalypts;
- their arrival in the two gardens was almost at the same time each evening. Possibly the bats left the Botanic Gardens in Melbourne at dusk, feeding at 'random' on fruits and nectar in other gardens on their way to Mitcham;
- that in spite of several *Eucalptus* sp. flowering in the Mullum Mullum valley nearby, none produced the volume of flowers and the density of foliage protection as did the two Eucalypt food plants previously mentioned;
- that this 'appears' to be the first record of Grey-headed Flying Fox sighted in Mitcham. It does appear that they are extending their range from Melbourne in their search for food;
- that in spite of a dog on the larger property barking intermittently during feeding they were not 'put off their food'. The barking ceased when I asked the owners to kindly keep the dog inside at night, which they gladly complied with, being as delighted as I with their nocturnal visitors;
- that in spite of a den of foxes between the two properties and a lot of fox activity in Mitcham they managed to survive. In fact, feeding on my property was as low as 2 m when the plums up higher in the tree had been eaten.

We have a high population of cats around my house with two immediate neighbours owning four between them. It was infuriating one night to watch one of the cats stalking the bats, needless to say I intervened. The bats, feeding quite noisily at the time, were unaware of the danger. Still, in spite of dogs, cats and foxes, the seven animals survived.

The Grey-headed Flying Fox seems to be extending its feeding locations further than previously recorded until my observations in Mitcham, which is a first, as far as we know. I would like a response from readers of *The Victorian Naturalist* as to their own observations in the eastern suburbs and beyond if possible. I am particularly interested in the food preferences of the Flying Fox. Mr Peter Menkhorst would also appreciate any information in future on distribution etc. and he can be contacted at the Department of Conservation and Natural Resources, 123 Brown St, Heidelberg, Victoria 3084.

Cecily Falkingham
27 Chippewa Ave, Mitcham, Victoria 3132

Trees of Victoria and Adjoining Areas (Fully revised 5th Edition)

by Leon Costermans

Publisher: *The Author. 1994.*
176 Pages, 7 pages colour photographs. RRP $12.00.

There can be few Victorians interested in the outdoors and more particularly in learning about the surrounding bush who have not treasured and carried with them, a copy of 'little Costermans' 'Trees of Victoria: an Illustrated Field Guide'. For me this genuinely back pocket-sized book was indispensable when we first came to Australia and all eucalypts seemed to look disconcertingly alike. That was back in 1966, the year in which the original was published. Since then we alone must have accounted for several of the 120,000 copies which have been sold - we've worn them out, given them away, there's one in the house, one in the car etc.

This new revised edition, which brings in more of the areas adjoining Victoria (after all, plants know no political boundaries) has already, in only a few months, sold out its first printing. The highly successful and accessible format of the 1966 original has been largely retained with, for the eucalypts, detailed line drawings of leaves, bark and buds, plus an overall sketch of the form of the tree, plus a black and white photograph of the general bark type.

The language is simple, with a glossary for those terms that have been necessary, and like elsewhere in the book there is excellent cross-referencing. Like the equally valuable 'big Costermans' - 'Trees and Shrubs of Southeastern Australia', this is a book not just to name plants, but one from which you genuinely learn, in that the plants featured are grouped according to their relationships, not by the botanically meaningless criterion of the alphabet!

In addition to the drawings which allow easy identification, there is now a section reflecting the growing interest of the human community in both ecological relationships and diversity of vegetation types. Simple line drawings of vegetation profiles are used in this section along with descriptions of soils and typical localities for each vegetation type. In my opinion, this sort of information is enormously important if we are to develop a truly caring and responsible attitude to our bushland. No longer is it just enough to name a plant and move on to the next specimen. It is to Leon's great credit that he has been able to encompass both approaches so clearly and pleasurably in such a small and inexpensive volume. We are all, beginners and those more advanced, in his debt as a result. Thank you Leon.

Jane Calder

Shell Collecting

Noel Schleiger[1]

Activities

'Shell Collecting' is usually confined to collecting along coastal beaches although the enthusiast will include freshwater examples. 'Collecting' should be restricted to dead, or observations of living animals. You should be aware of the restrictions on the removal of **any** material in some areas. Appropriate permits should be obtained - refer to clubs listed below.

As a Field Naturalist specialising in 'shell collecting' you can look forward to participating in:

- Field collecting trips;
- Participating in surveys;
- Making your own collection;
- Studies of species behaviour;
- Recognition of fossil shells in old marine deposits;
- Conservation of species;
- Conservation of habitat;
- Studies of shell associations.

Field Guides/Handbooks

Australian Sea Shells. J. Child. (Periwinkle Press: Sydney).
What Shell is That? Neville Coleman. (Lansdowne Press: NSW).
Marine Invertebrates of Southern Australia. (Eds.) S.A. Shepherd and I.M. Thomas.
Australian Sea Shores. W.J. Dakin. (Angus & Robertson: NSW).
Marine Molluscs of Victoria. National Museum of Victoria. (Melbourne University Press).
Coastal Invertebrates of Victoria. Marine Research Group of Victoria and National Museum of Victoria.
Life on the Rocky Shores of Southeastern Australia. Victorian National Parks Association, Melbourne.

Equipment

Hand lens (10 or 20 magnification) for looking at detail on shell specimens. ***Plastic bags, labels, water-resistant pens*** and ***plastic ties*** are essential for collecting for later analysis. ***Look-box*** or ***face mask*** for observations in rockpools. ***Camera,*** photography is important for illustration and study. ***Sketching equipment,*** sketches can bring out features not seen in photographs.

Clubs and societies

Marine Research Group
Malacological Society of Victoria
FNCV

Journals

Journal of the Malacological Society of Australia, produced annually and deals with Mollusca.
Australian Shell News, produced quarterly, related topics.
The Victorian Naturalist, occasional articles on marine life.
Field Nats News (Newsletter of the FNCV), produced monthly, occasional articles on field trips.

Enquiries

Your FNCV contact for *shell collecting* is Noel Schleiger and you can contact him on (03) 435 8408.

[1] 35/20 Were Street, Montmorency, Victoria 3094.

A Tribute to Alex Burns

Dear Editor

The news of the death of Alex Burns saddened me indescribably. He had been a good friend to me. For several years, it has been on my mind to write to Alex but I have not done so, simply because I had no address and never developed the energy to get in touch with someone who would know. Now it is too late and I have never made due acknowledgement of an ancient debt.

I was admitted as an associate member of the FNCV on 13 December 1920. My special interest was Lepidoptera. Very shortly after joining, I was introduced to Alex. Although Alex was then aged in his early twenties and I was eight years younger, we became friends and almost immediately I was visiting him at his home in Lower Ferntree Gully. The Burns property fronted Dorset Road and was backed by the railway line, so the way to it was by foot along the rail track about a half mile from the Lower Ferntree Gully Station. Alex lived in the farm house with an older, much older, brother and sister. As I remember his story, when he was born his mother was remarkably old, in her middle fifties.

For a young man of 22, a boy of 14 is still a child, but never did Alex treat me, discuss with me, talk to me about any subject other than as with an equal. Even on the subject of butterflies, with me, he took the role of guide rather than that of an expert. He included me in many of his excursions. Several times with Charles French Jr., we went to Springvale where there was then natural bush country adjoining the old race track. Each time, our quarry was the pupae of what we called then *Miletia delicia*, (now *Hypochrysops*) to be found on *Acacia mearnsii*. That was the only way to collect them; butterflies never came below the higher branches of the food plant and so were impossible to net.

We went together to Mount Donna Buang. Alex was making his own survey of the incidence of Macleays Swallowtail. So it was by train to Warburton, a night's rest in a shopkeeper's spare room and then, early in the morning, a hike straight up the mountain on a timber tramway which took us to the mountain road three or four km from the summit. No vehicles used the road that summer. The road was strewn with eucalypts brought down by winter snow, making it hard work for us to climb over them all.

Several times too, we went to the Moorooduc Railway Station and from there walked the high ground back to Frankston, or several times once with Len Thorn, who got stung by a scorpion, to Woori Yallock RS and from there by bush to another station which, I think, was Seville, or once from Yarra Junction over the Don Gap to Healesville, a long walk. We wandered the open grassy country around the Broadmeadows RS, or, with Charles Barrett to the heathlands near the Cheltenham RS. Always Alex had something specific in mind, always I learned much, not only of butterflies but also of native species, zoological and botanical.

Mentioning Len Thorn's casualty reminds me of Charles Oke, for some time the Club's secretary. His interest was spiders and he was questioning the dangers attributed to spider bites. To satisfy himself about the subject, he teased all kinds of spiders into sinking their fangs into him. He experienced no adverse effect. Then, in discussion, he mentioned he was going to experiment with a Red-Back. Some of the audience at the FNCV meeting were shocked. Then, and later he received so many reports of first-hand very adverse experiences of Red-Back bites that he desisted. Years later it struck me; his inoculation by minor bites may have had the effect of inuring him to every kind of bite. But as he desisted, how can we form an opinion?

As I write, it comes to mind, in 1922 my mother took me for a fortnight's holiday to Double Bay. It so happened, at that time Alex was also in Sydney. Together he and I explored St Georges River to find, under the waterside rocks, the largest centipedes and scorpions I have ever seen. Another day we took the tram from Manly to Narrabeen. This tram ran mostly not along a road at all, but through heath and low ocean-side scrub. My memory tells me after leaving the precincts of Manly, we saw very few houses until we reached the village of Narrabeen.

Around 1929, I allowed my membership to drop, but rejoined the club in 1938. In the thirties, Alex worked from an office near my city address, 430 Little Collins Street. Despite my not having seen him for some years, our friendship was as ever. It is here that I think I find a minor error in Sheila Houghton's account as to the beginning of Alex's interest in orchids. It was in the early thirties that Alex had an orchid house at his Blackburn home. This was very helpful to me. It was a time when, if you were taking out your girl of the moment to anything special, you gave her a corsage to wear. The centre flower was most commonly a gardenia or a cyclamen and, because they were hard to find, rarely an orchid. I had the great advantage that Alex would bring to the city for me an orchid (*Dendrobium*, *Cymbidium* or *Cattleya*) for the low price of two shillings. In the florist an orchid cost at least seven and sixpence and, as that was about the price of a front stalls seat at the theatre, it was for any young fellow a lot of money. A friendly florist would complete the posy.

A couple of times I visited Alex at Blackburn. In addition to his orchid house of which I remember only that he had a variety of epiphytes including several species of *Miltonias* which I had not ever seen before, he had an amazing garden on the north side of his house. It was a garden with literally an unexampled variety of tropical species growing there healthily in the open. Alex had spent much time in Queensland, an area always attractive to him, if only because of its large population of handsome butterflies. I asked him how he managed to persuade north Queensland species to grow so well in Melbourne. His recipe: give them copious water in summer and keep them as dry as possible in winter. Some years later, after I married, I had a north facing corner in our house in Kew and I tried Alex's idea - quite unsuccessfully.

I cannot remember why I let my membership lapse. Perhaps it was because the thirties were very difficult years. And then the war came. I think Alex moved to Queensland, I am not sure. But I completely lost touch with him, seeing him again in Melbourne purely by chance only twice. All the same our meetings were just as though we had parted the day before.

I have never forgotten the debt I owe Alex and with him many other members of the Field Naturalists Club; Edward Pescott, Charles French, Bert Clinton, Miss R.E. Chisholm, Charles Daley, are just a few that spring to mind. I have often wondered how they may have discussed having this brat along with them on three summer camps in the years 1923, 25 and 28 to Wilson's Promontory.

In my later membership Crosbie Morrison, Stan Colliver and the Saroviches come high in my memory. Stan was then the Club secretary and intense in his study of palaeontology. In addition to all that entailed, one Sunday each month Stan enthused us by having a gathering of young (and not so young) Club members to his Essendon home where, over time, we discussed every aspect of nature study. The exigencies of war brought those meetings to an end.

In short, these people, and no doubt first among them Alex Burns, enriched my life to such an extent that even now, daily, I experience the benefit. And it is probable that one could trace the line of causation from those early influences that we have now retired to this high Strzelecki country where our home is now surrounded by the Tarra Bulga National Park, much of it in a near pristine state.

I could only wish that more young people would be attracted to the Club. But to do so artificially would be very difficult and perhaps not at all effective. How to stimulate one from within is a moot problem indeed.

Cedric Ralph
RMB 7560, Balook, Victoria 3971

Australian Natural History Medallionist is Honoured in the 1995 Australia Day Honours List

Associate Professor Michael James Tyler was made an Officer of the Order of Australia for services to zoology, in particular, his work with Australian amphibians.

Michael Tyler was the Australian Natural History Medallionist in 1980.

Australian Natural History Medallion Trust Fund

The following donations were gratefully received during 1994:

Valda Dedman	$ 10
Stawell Field Naturalists Club	$ 10
Royal Society of Victoria	$100
Ballarat Field Naturalists Club	$ 25
Peninsula Field Naturalists Club	$ 5
Helen Aston	$100

If you would like to contribute to this fund which supports the Australian Natural History Medallion, donations should be sent to: The Treasurer, The Field Naturalists Club of Victoria, National Herbarium, Birdwood Avenue, South Yarra, Victoria 3141. Cheques should be made payable to the Australian Natural History Medallion Trust Fund.

The Medallion is awarded annually to a person who is considered to have made the most significant contribution to the understanding of Australian natural history in the last ten years.

Sheila Houghton

Membership Rates 1 January 1995 to 31 December 1995

INDIVIDUAL (ELECTED MEMBERS) MEMBERSHIP

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Thank You Robyn

Council and members of The Field Naturalists Club of Victoria wish to express their appreciation for the time and hard work put in by Robyn Watson as Editor of *The Victorian Naturalist* from 1989 to 1995. Her experience and professional knowledge contributed to maintaining the high standard of the journal.

New Members

Members

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Cover: Drooping Mistletoe *Amyema pendulum.* Photograph courtesy James Calder. (see article on page 134)

New Perspectives on the Ecology of Lake Mountain: The Discovery of Leadbeater's Possum *Gymnobelideus leadbeateri* McCoy in Sub-alpine Woodland

Ann Jelinek[1], David Cameron[2], Christopher Belcher[3] and Lucille Turner[2]

Introduction

Lake Mountain plateau is situated at the western limit of the Australian alps in south-eastern Australia. It is biogeographically important and also has conservation significance at all levels - national, state and regional. This is indicated by the concentration of rare and disjunct populations of species and communities, and the concentration of species and communities, particularly plants, at the geographic and ecological limits of their range (CNR 1994).

Although no comprehensive ecological surveys have occurred at Lake Mountain, recent flora and fauna surveys of the Long Heath-Echo Flat area highlight new ecological information, including the discovery of Leadbeater's Possum, *Gymnobelideus leadbeateri* McCoy, in sub-alpine woodland. These surveys were completed as part of an assessment of the environmental impacts of two proposed cross-country ski trails at Lake Mountain in December 1993 (CNR 1994).

This paper reports the discovery of Leadbeater's Possum in sub-alpine woodland and results of two subsequent Leadbeater's Possum stagwatch surveys (*sensu* Lindenmayer *et al.* 1989) carried out with The Field Naturalists Club of Victoria.

Further details on methodology, taxonomy and results of the environmental assessment are given in CNR (1994).

Study Area

Lake Mountain (37°31′S 145°53′E) is north-east of Melbourne and 20 km east of Marysville in the Central Highlands of Victoria. High average annual precipitation of around 1400 mm per annum occurs, with frequent snow falls during June to October (Land Conservation Council 1991).

The study area is 2.5 km north of Lake Mountain summit. It includes approximately 90 hectares of the Long Heath plateau between 1400 m and 1440 m asl, including two tributaries of the Taggerty River, and a small area of approximately 12 hectares at the head of the Royston River catchment between 1420 m to 1450 m asl.

Leadbeater's Possum in Sub-alpine Woodland

Leadbeater's Possum is listed as 'endangered' on Schedule 1 of the 'Endangered Species Protection Act', 1992 and is listed as a threatened taxon on Schedule 2 of the 'Flora and Fauna Guarantee Act', 1988. The species is also classified as 'endangered' by IUCN (1993) and 'endangered' by CNR (1993). Extensive surveys indicate that Leadbeater's Possum is predominantly confined to the montane ash forests in the Central Highlands of Victoria (Lindenmayer *et al.* 1989; Lindenmayer and Dixon 1992; Macfarlane and Seebeck 1991).

Leadbeater's Possum. Note that the white piece hanging down below the branch is bark.

[1] Australian Nature Conservation Agency, Endangered Species Unit, GPO Box 636, Canberra, ACT 2601.
[2] Department of Conservation and Natural Resources, 123 Brown St, Heidelberg, Victoria 3084.
[3] ECOSYSTEMS, RMB 7285 Timboon, Victoria 3268.

In early December 1993, at 1500 h, three Leadbeater's Possums were disturbed from a one-metre-high hollow in a Snow Gum (White Sallee) *Eucalyptus pauciflora* stump in sub-alpine woodland at the head of the Royston River catchment (Fig. 1). After a short time climbing the nearby Snow Gums and leaping from trunk to trunk, the animals retreated to the original stump and another that was 0.75 m high. Each stump had small hollows at 0.5 m and 0.25 m above the ground respectively. One stump was associated with two other dead coppice stems, the other was associated with two live and three dead coppice stems. The stumps ranged from 20-30 cm diameter and one of the entrances part way up the stump was distinctly chewed (see Lindenmayer 1989).

A subsequent stagwatch in early March 1994, involving 17 observers, recorded five Leadbeater's Possums (two groups of two animals and one individual) spread over part of the same area and all within sub-alpine woodland. One possum group was sighted at dusk, the others were seen after dark. The possums were observed climbing Snow Gums and acacias or moving through the understorey shrubs. No animals were recorded during another stagwatch in late March 1994 with 13 observers in an adjoining area to the west of the Panorama Trail, where one possum was spotlighted during the previous stagwatch.

Habitat Characteristics

In the study area, Leadbeater's Possum was recorded between 1420-1445 m asl on a ridge in the headwaters of the Royston River. A montane ash forest dominated by Alpine Ash *Eucalyptus delegatensis* is situated 350 m to the east of the most north easterly sighting. These sites are separated by a rocky escarpment, wet sub-alpine heathland and sub-alpine woodland.

Multi-stemmed Snow Gums with connecting canopies dominate the sub-alpine woodland which also includes mainly mature, scattered Mountain Hickory Wattle *Acacia obliquinervia* of 5-8 m in height. Average basal area of *A. obliquinervia* in the area is approximately 3.5 m^2/ha, although clumps of acacias do occur.

Fig. 1. Snow Gum stump from which three Leadbeater's Possums emerged.

There is abundant evidence throughout the sub-alpine woodland community in the study area that the density of *A. obliquinervia* was high until quite recently, and that most individuals of the currently senescing age class have recently died and most have already collapsed. Therefore, stands with an understorey of *A. obliquinervia* are increasingly uncommon in the sub-alpine woodland community of the Echo Flat-Long Heath area.

Three of the Leadbeater's Possums were sighted near the highest part of the ridge at approximately 1445 m in shrubby sub-alpine woodland. The most elevated and exposed stands of shrubby sub-alpine woodland, on dry flat ridgelines and north-west aspects, are characterised by widely-spaced, broad-crowned *E. pauciflora* and a discontinuous shrub stratum with a distinctive herbaceous flora in the intervening gaps. Shallow soils and occasional outcropping rock account for the gaps in the tree and shrub strata.

These stands of shrubby sub-alpine woodland are significant on account of their rather restricted occurrence and because their structural and floristic heterogeneity contributes to the highest stand biodiversity recorded for sub-alpine woodland vegetation within the study area. This significant form of shrubby sub-alpine woodland is also at the ecological and altitudinal limit of this vegetation type in the Lake Mountain area (CNR 1994).

The vegetation around the stumps, from which the Leadbeater's Possum emerged, represents a grassy and herbaceous form of sub-alpine woodland in which the understorey is dominated by the grass *Poa ensiformis*, which has an estimated cover of 40%, together with a suite of forbs of which the most common are *Asperula pusilla*, *Hydrocotyle hirta* and *Leptostigma reptans*. Shrubs are scattered and poorly represented. *Eucalyptus pauciflora* forms a continuous and uniform canopy of 15-18 m in height and estimated cover of 35%. The current stems of *E. pauciflora* apparently represent a single age class, mostly multi-stemmed and often including both living stems of canopy height and self-pruned stags or stumps arising from the same lignotuber. These observations are consistent with the interpretation that the stand regenerated prolifically following the 1939 wildfires.

This stand occupies a well-drained mid-slope site of uniform 5% (estimated) slope, NNE aspect and 1425 m elevation asl. Stand diversity is low with only 22 vascular species and ten non-vascular cryptogams (4 mosses, 4 liverworts and 2 lichens) recorded within one quadrat. Four species (*Orites lancifolia*, *Ozothamnus secundiflorus*, *Prostanthera cuneata* and *Uncinia flaccida*) are considered regionally significant by Beauglehole (1983) but these are all widespread within sub-alpine woodland at Lake Mountain. No plant species of state or national significance were recorded.

Distribution and ecology

The Atlas of Victorian Wildlife (1994) has several records for Leadbeater's Possum in montane areas around Lake Mountain, including the Lake Mountain summit area. Leadbeater's Possum has previously been recorded approximately 1.8 km to the east at 1180 m in Alpine Ash (D.B. Lindenmayer *pers. comm.*) and 3.2 km to the south at approximately 1420 m, in the Snow Gum/Alpine Ash ecotone (Jenkin and Thomas 1991; D.B. Lindenmayer *pers. comm.*). A sighting of Leadbeater's Possum in sub-alpine woodland on Mount Baw Baw in 1971 is reported in Lindenmayer (1989). However, there are no records of Leadbeater's Possum at Lake Mountain in sub-alpine woodland, distant from *E. delegatensis* or the Snow Gum/Alpine Ash ecotone, that is, outside their potential home range.

The importance of sub-alpine woodland for the conservation of Leadbeater's Possum and the habitat requirements and home range of Leadbeater's Possum in this habitat are not known. As the sub-alpine woodland is under snow for three to four months each year, it is possible that Leadbeater's Possum may use this habitat only on a seasonal basis. Snow Gum stumps and old, dead coppice branches may provide suitable nest sites. Lindenmayer (1991) demonstrated that Leadbeater's Possums use particular trees with hollows over many years, although it is not known whether these hollows are in continuous use. Leadbeater's Possum often change nest trees, some of which are occasionally shared with other arboreal mammals (Lindenmayer *et al.* 1990a).

Leadbeater's Possums nesting in low stumps could be vulnerable to predation and the loss of a connected canopy fragments their habitat, although proximity of tree trunks may be even more important for movement. Loss of these features could increase their susceptibility to predation because they lack a gliding membrane and thus, in areas without a connected canopy or stem proximity, they need to descend into the understorey or to ground-level to move between trees. Thus, considerable care needs to be taken in planning and constructing ski trails which involve changes to the vegetation structure and cover.

The sap from *Acacia obliquinervia* is an important food source for Leadbeater's Possum (Smith 1984; Lindenmayer *et al. 1994). Fresh bite marks on several A. obliquinervia* near the potential nest sites of Leadbeater's

Possum indicate that they may be extracting sap from this species.

Snow Gums have abundant loose bark which provides a suitable environment for invertebrates. Arthropods and other invertebrates are an important protein source for Leadbeater's Possum and their abundance may directly influence breeding success (Lindenmayer *et al.* 1990b). Given the low density of acacias and abundance of other insect feeders, invertebrates could be an important food source for Leadbeater's Possum in sub-alpine woodland at Lake Mountain.

The major populations of Leadbeater's Possum occur in the montane ash forests of the Central Highlands. These populations are critical to its future conservation (Lindenmayer and Possingham 1994). However, further study of Leadbeater's Possum in subalpine woodland is needed. This may assist with developing long-term conservation strategies using population viability analysis to determine effective reserve systems and management prescriptions for the species (Lindenmayer and Possingham 1994).

Acknowledgements

Special thanks are extended to members of The Field Naturalists Club of Victoria (Fauna Survey Group) and the Upper Goulburn Field Naturalists who endured the chilly mountain air during two nights of stagwatching and spotlighting.

The authors gratefully acknowledge the constructive comments and information provided by Dr D. B. Lindenmayer.

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Revegetation of Habitat for the Helmeted Honeyeater, *Lichenostomus melanops cassidix*, in the Yarra Valley

Gaye Gadsden[1] and Mark Ashby[2]

Introduction

The Helmeted Honeyeater population is now restricted to a small area drained by Cockatoo Creek, approximately 50 km east of Melbourne. The former range of the bird covered some 3,000 sq km within the Western Port and mid-Yarra catchments.

Helmeted Honeyeaters are specialised foragers of riparian forests and require dense understorey vegetation for nesting. The primary cause of the decline in the bird's population and distribution is the destruction and degradation of these wide-spread vegetation communities since European settlement, practices which continue today with increasing efficiency.

By 1965 most of the remaining Helmeted Honeyeater population was found along three creeks in the Yellingbo area. The Victorian Government duly proclaimed narrow stream-side remnants along the Woori Yallock, Cockatoo and Sheep Station Creeks as the Yellingbo State Nature Reserve (Backhouse 1987).

Revegetation of habitat for the endangered Helmeted Honeyeater population in the Yellingbo area began in 1978 (Smales *et al.* 1990). Since 1975, cleared land bordering the reserve has been purchased to consolidate its boundaries and incorporate habitat fragments. Revegetation of this cleared land has the objectives of increasing habitat within the reserve and providing a buffer zone between the reserve and surrounding agricultural land. Between 1978 and 1987 the Bird Observers Club, the Society for Growing Australian Plants and the State Government Conservation Department (term is used since the Department has had several name changes over the period) planted approximately 80,000 trees and some shrubs (Backhouse 1987). Sites revegetated during this period are, with few exceptions, devoid of a shrub layer (McMahon and Carr 1992). The intent was to introduce an understorey once the tree layer had become established but this has not yet been done (Ian Smales *pers. comm. 1994).*

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By 1988, with the continued decline of the Helmeted Honeyeater population, it became apparent that protecting and expanding habitat within Yellingbo State Nature Reserve was not sufficient to save Victoria's avifaunal emblem (Smales *et al.* 1990). In 1989 the Helmeted Honeyeater Recovery Team was formed to direct the intensive management effort required to halt the decline of the population.

In May of that year more than 300 Victorians responded to a multi-media campaign to enlist community support for the Helmeted Honeyeater and attended a public meeting in Lilydale. Friends of the Helmeted Honeyeater Inc. (FOHH) was founded. The group was formed to encourage people to participate in activities designed to:

a) increase public awareness of the endangered status of the Helmeted Honeyeater;
b) improve the status of the Helmeted Honeyeater in the wild, and
c) assist with the conservation of the Helmeted Honeyeater in the wild.

In this paper we will report on FOHH's experience in revegetation on both private and public land. This information is presented to demonstrate the evolving nature of such projects.

The rapid learning curve

Priorities were quickly set within the revegetation sub-group of FOHH. With only 38 known birds, FOHH sought to work in the area immediately surrounding the population. It was decided that efforts were best directed at private landowners in the Yellingbo area and to leave revegetation responsibilities within Yellingbo State Nature Reserve to the State Government

Conservation Department. In addition, it was believed at this time that the population was being limited by a lack of winter nectar sources (Wykes 1982) and upslope foraging requirements were not represented in the reserve when FOHH was formed.

An information day, advertised through the local media, attracted a dozen interested land-holders whose properties abutted or were close to the reserve. A major incentive for land-holders to revegetate was the FOHH's offer to contribute 90% of material costs plus voluntary labour. Land-holders have had a variety of reasons for wanting revegetation works on their land which included the conservation of flora and fauna, an enhanced property value, creating a screen of vegetation and even, in one case, assisting political ambitions! By 1991, thirteen properties had been assessed, but revegetation on several has not yet eventuated. Some properties were too far away from recent or extant Helmeted Honeyeater sites to warrant immediate attention and in other cases the land-holders' aims for the area were inconsistent with the aims of FOHH. For example, one land-holder wanted to continue grazing in proposed revegetated sites.

To ensure that land-holders and FOHH intentions coincided, an agreement, to be signed by both parties, was drawn up by FOHH based on that used for the DCNR Land Protection Scheme. The agreement comprises a property description, description and sketch map of the site, a costing of the project and a set of conditions to which both parties must adhere. The format has worked well and is still used.

Information about local vegetation communities was limited and specific to only a few plant species. FOHH obtained aerial photographs to determine the extent of remnant vegetation and conducted its own surveys of local vegetation.

Subsequently seed was collected with the aim of re-establishing as wide a range of appropriate species as possible. A lot of time was invested in learning the seed dispersal habits of the local flora, the seasonal variations of those habits and in refining methods of collection and extraction. Loppers, ladders, tree climbing with spurs and a .22 rifle were all experimented with to obtain seed which could not be reached from the ground. Collecting seed from fallen branches after a strong wind is now the most common method used for these 'hard to reach' species.

During this time FOHH contacted wholesale nurseries, seeking voluntary assistance with plant propagation. Nurseries from Ringwood to Bittern responded and FOHH received many thousands of plants via this method but several difficulties arose. These included oversupply of some species and under supply of others with few species available at any one time and also a problem in matching sites to available stock. Consequently FOHH often had to revegetate those areas for which suitable stock was available, including sites within the reserve.

Efforts culminated with the first planting held in Yellingbo State Nature Reserve on Arbor Day 1990. Over 100 people attended the weekend including Scout and school groups. The first planting on private land, which had been delayed by lack of insurance cover, took place in October 1990 at 'Yellingbo Farm', owned by A. and A. Tegel. The 20 species planted consisted of overstorey and shrub species in an area fenced by FOHH to exclude stock.

Planting methods were dictated by site conditions, a small budget and FOHH's commitment to chemical-free weed control methods. Freehold sites are invariably on exotic pasture with its corresponding suite of vigorous introduced species. Sites were mown prior to planting. To control competition from exotic grasses at the least possible cost, approximately half a square metre of turf was removed with a mattock, then the inserted plant was surrounded by a newspaper weed mat. The sods of turf removed during the scalping process were inverted on the corners of the weed mat to secure it.

Obtaining finance from limited sources also involved hard work. Fundraising items were produced and sold, suppliers of materials were approached for sponsorship and the local Shires of Lillydale and

Sherbrooke contributed in kind to FOHH efforts. Submissions were presented for grants and TreeVic provided initial funding for fencing materials, fencing tools and tube stock.

The successes and indeed survival of FOHH during this first year can be attributed to the intensive dissemination of information by the group. This campaign included media releases, bulk dispatching of letters, public information days, plant identification workshops for members and invitations to each of the 400 members to attend activities.

From strength to strength

Sites

FOHH has revegetated approximately 10.5 ha of degraded habitat to May 1995 including 5 ha on nine sites within Yellingbo State Nature Reserve. Since there are many sites which need revegetating within the reserve, when planting cannot be done on freehold sites FOHH can quickly arrange planting on an alternative site. Although planting within the reserve was not the original aim of the revegetation sub-group it was decided that since artificial boundaries are irrelevant to wildlife, planting should occur where the need arose.

Projects on private land have been undertaken on 10 properties in the area, leading to the revegetation of some 5.5 ha and erection of 3 km of fencing. Revegetated areas provide a variety of ecological functions: extending habitat; linking stream side remnants; arresting stream bank erosion; increasing the viability of roadside remnants; creating a vegetative buffer between the reserve and areas of intensive agriculture, and preserving the local floristic gene pool.

Another major recruitment drive for landholders was made in mid 1991, a project shared by FOHH and the regional DCE Land for Wildlife Extension Officer. Letters were mailed to 80 property owners with land between Woori Yallock Creek and Cockatoo Creek. Owners were offered the opportunity to assist the Helmeted Honeyeater by joining the Land for Wildlife program or allowing the Friends either to replant vegetation or protect remnant vegetation from grazing. There are now 46 properties registered in the Land for Wildlife program within the Cockatoo and Woori Yallock Creek sub-catchments. FOHH has assisted with revegetation on three of those properties and fenced off a riparian-zone remnant on another.

Site preparation and maintenance

In mid 1993 FOHH replaced mechanical site preparation with chemical preparation. The scalping method produced high survival rates but was physically too demanding for most volunteers. Also the exotic grasses, retained in the sods securing the newspaper weed mats, found the decomposing paper to be an ideal rooting medium. Sites are now spot sprayed with glyphosate prior to planting. However, FOHH remain uneasy about the possible deleterious effects of herbicides on components of the ecosystem such as soil fauna and amphibians.

Sites are maintained by hand weeding and dead plants are replaced. Plant survival rates vary enormously from 20% to 90%, the majority being around 80%. Eutrophication, competition from exotic grasses and browsing are the major causes of plant loss. Other losses have occurred from repeated flooding, careless application of herbicides on neighbouring properties, trampling by recreational anglers and slashing by service instrumentalities and government agencies. Substantial nutrient loads carried by run-off from adjacent land has resulted in high mortality of *Eucalyptus* and *Acacia* species on some sites. These areas are replanted with more nitrogen tolerant *Melaleuca* species. While this results in less representative planting, it at least provides a buffer between natural remnant vegetation and areas of intensive agriculture. *Melaleuca* species can be thinned at a later date to introduce a more desirable assemblage of species.

In the presence of vigorous, exotic pasture grasses, the native seedlings often suffer from stem rot and slug and snail attack and, in the competition for light, either death or poor form development. Pasture grasses are therefore removed by hand from around the base of plants until the native species have become established above their exotic competitors.

Inadvertent grazing from both sheep and cattle has occurred on freehold sites where stock gained entry through temporary fences while rabbits, wallabies and deer are more likely to cause damage on sites within Yellingbo State Nature Reserve. FOHH has used tree guards on only one site because of the high cost and labour involved in guarding. Rabbits have not been a problem on most sites but where they were, a 4-foot-wide netting fence was used successfully to minimise damage. Approximately half the width of the mesh was laid horizontally along the ground, bending away from the revegetated site.

All sites are visited once a year in Autumn for photo monitoring. The photographs are used for progressive comparison purposes.

Species selection

Consultants were employed by the Helmeted Honeyeater Recovery Team in 1991 to document vegetation within Yellingbo State Nature Reserve, identify vegetation management issues and to prepare a revegetation strategy. McMahon *et al.* (1991) recorded 11 vegetation communities including seven sub-communities within the reserve.

FOHH replants assemblages of species from several of the identified plant communities. In general, assemblages are dominated by *Eucalyptus viminalis, E. ovata, E. camphora, Leptospermum* spp. and *Melaleuca* spp. These assemblages contain the principal foraging and nest-site plants of the Helmeted Honeyeater, as collated by ornithologist Don Franklin (McMahon *et al.* 1991).

Species selection for a site is determined by existing remnant vegetation (if any), drainage, aspect, perceived nutrient load entering the site and the quantities of species available. While it is desirable to propagate species on a site-by-site basis, when planting on private land in a high rainfall area, delays often occur which make this level of planning unworkable.

Plant propagation

Seed is collected within the sub-catchments as the opportunity arises. Within the group there is still a debate on how far from the proposed revegetation site it is acceptable to select seed plants. This dilemma has been resolved to some degree by adopting a 'close-as-possible' rule which still allows for intra-species diversity. However, the choice of seed collected is subjective and left to the discretion of the collectors.

Since procurement of plants from commercial nurseries was sporadic and inconsistent, FOHH sought funding for a community nursery to be sited at Healesville Sanctuary. Three other Yarra Valley conservation groups shared in the submission and funding was received from TreeVic in April 1990. Members with commercial nursery skills enabled the nursery to be established at minimal cost. While still maintaining a stake in the Healesville facility, FOHH has set up other facilities at the Yellingbo Reserve and the first seedlings were propagated in 1992.

Initially FOHH members had limited knowledge of indigenous plant propagation methods but through experimentation, contact with other community nurseries and, more recently, Greening Australia, expertise has increased to such an extent that FOHH funds are occasionally augmented with propagation contracts. Plants are sold to government agencies for local projects and to land holders within the area.

During 1993, FOHH volunteers attending four nursery days a month, produced around 30,000 tube stock. Almost all of the 45 species of trees and shrubs > 1 metre which occur in the Yellingbo/Macclesfield area are now propagated. Species and their required quantities are determined on an annual basis according to the sites available for revegetating with a planting rate of about a thousand tubes each activity day. Surplus stock is donated to DCNR for planting within the reserve by their staff and school groups on weekday excursions.

Planting

FOHH held revegetation days every week for the first few months, but the works group could not maintain the organisation and volunteer enthusiasm needed to keep up such an intensive program. Twelve revegetation days are now held per year, avoiding the hottest summer months and holding two per month in the more favourable seasons of autumn and spring. In late 1993, mattocks were replaced with Hamilton tree planters when the switch to chemical site preparation was made. The number of plants going into the ground doubled. However, survival rates have fallen.

FOHH revegetates sites at a density of approximately 10,000 plants per hectare. While overstorey species are spaced at approximately 3 m intervals, species such as *Leptospermum continentale* and *Melaleuca squarrosa* are planted in thickets of up to 6 plants per square metre.

Other community groups have collectively contributed thousands of hours labour to FOHH projects. Primary, secondary and tertiary students, Scouts and Venturers and other local interest groups have regularly helped the ten to twenty FOHH members who have formed the core revegetation group.

Funding projects

Revegetation works have been resourced by a substantial voluntary commitment, fundraising, state and federal grant programs and donations of materials. Based on estimates for 1993, FOHH contributes some $80,000 a year to revegetation in terms of labour, investment in equipment, the provision of plants and expenses for telephone and travel. Additionally, over the past five years FOHH has received approximately $15,000 through various grant programmes for plant propagation and revegetation .

Co-ordination

As early as 1990 it was apparent that a voluntary part-time committee and membership could not keep up with the level of community interest in the conservation of the Helmeted Honeyeater. Submissions to funding bodies to employ a part-time co-ordinator were lodged in 1991. Funding of $15,500 per annum has been received for the past two years from the federal 'Save the Bush' program. A successful application has been made to the 'National Estate Grants Program' to continue the position in 1995. The co-ordinator provides support to the revegetation convenor and nursery supervisors by assisting with the planning and implementation of revegetation projects and nursery operations. With the creation and maintenance of a high public profile, the group receives many requests for further information and offers of help. By employing a part-time co-ordinator FOHH has been able to respond quickly to such requests and thereby maintaining the group's momentum. With a full-time co-ordinator FOHH could work over a wider area within the Helmeted Honeyeater's former range, restoring habitat at a greater rate and with more efficiency.

Unsolved problems

Incremental clearing of natural vegetation on freehold land, public land water frontages and roadsides surrounding Yellingbo State Nature Reserve continues at a rate far greater than that at which land is being revegetated. In addition to remnant vegetation cleared under permit for 'developments', substantial vegetation is lost due to inappropriate road maintenance, fire prevention works, illegal firewood collection, fence re-alignment, stock access to streams and utility maintenance; all of which repeatedly occur in this area. Despite efforts by many local FOHH members to arrest these problems, destruction of remnant vegetation continues as the human population of the area increases. Protected habitat currently occupied by the remaining Helmeted Honeyeater population is also under stress. Eucalypt dieback within Cockatoo Swamp is widespread and locally severe (McMahon and Franklin 1993) with little regeneration occurring.

Faced with these problems, it is imperative that FOHH integrate direct seeding methods into the revegetation program to maximise the area being revegetated. Direct seeding is not an option for the majority of sites that lie within riparian zones subject to annual flooding. However, direct seeding methods offer potential for rapidly establishing vegetation on the more elevated sites in order to provide continuous vegetation links between riparian-zone habitat remnants.

Small trials carried out by FOHH indicate that the 'brushwood' method of laying seed-bearing *Leptospermum continentale* branches over a scalped area, results in profuse regeneration. This method can also be applied to other Myrtaceae species.

Ideally, future FOHH projects would include groundstorey species in addition to trees and shrubs. The inclusion of indigenous ground flora would create a more complex ecosystem with a greater potential to support evolutionary processes in the local area. At present, the labour and expense involved in revegetating and maintaining ground flora over large areas adjacent to weed sources, such as pasture, is beyond the resources of the group.

There is no foreseeable limit to private or public land sites available for revegetation or restoration work within even a small radius of Yellingbo State Nature Reserve. FOHH hopes to retain enough support to continue its efforts to conserve the Helmeted Honeyeater population and other biota within the mid-Yarra catchment. It is hoped that, with time, these efforts will extend over much of the former range of the Helmeted Honeyeater.

Acknowledgements

We acknowledge all FOHH members who have assisted with fencing, seed collection, plant propagation and planting, in particular those members who initiated the revegetation project in the first 12 months. Thanks also to the former Yellingbo State Nature Reserve Ranger, Mick Keenan, who has constantly supported the work of FOHH, and to those people who provided comments on this paper.

If you would like to help or want more information on the FOHH, contact PO Box 295, Mt Evelyn, Victoria 3796. Tel: (059) 64 4494.

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Astelia australiana (Liliaceae): An Overview

Elizabeth James[1]

Tall Astelia, *Astelia australiana* (J.H. Willis) L. Moore, is a rare lily endemic to Victoria. It is listed as a threatened taxon on Schedule 2 of the Flora and Fauna Guarantee Act 1988. It was first recorded in 1929 when a colony was found by J.H. Willis near Powelltown. The following account summarises aspects of the species' distribution, abundance, ecology and threats, as reported in several recent studies.

The genus *Astelia*

The genus *Astelia* has approximately 27 species (Williams 1987) divided into three subgenera mostly found within the southern hemisphere (Moore 1966). The genus is generally placed in the family Liliaceae (Willis 1939; Williams 1987). *Astelia* has been placed in Asteliaceae by Dumortier (1829) (monogeneric), Harden (1993) (five genera including *Cordyline*) and by Dahlgren, Clifford and Yeo (1985) (including the genera *Milligania*, five species in Tasmania) and *Neoastelia*, a recently described monotypic genus from New South Wales. The genus was also placed in Asphodelaceae by Dahlgren and Clifford (1982).

Astelia was first recognised as a distinct genus by Banks and Solander during Cook's first voyage to New Zealand (1769-70) but the descriptions formulated of the three species were not published. The name, *Astelia*, was first published in 1810 by Robert Brown when he described the Tasmanian species *A. alpina* (Wheeler 1966). It is derived from the Greek, meaning 'without a trunk or pillar', referring to the habit of the plant in which leaves arise directly from a fleshy rhizome.

The mainly southern distribution of the genus and its frequent association with *Nothofagus cunninghamii* is thought to reflect its ancient origin in the rainforests of Gondwana, the southern supercontinent that broke up over 45 million years ago (Turner 1991). Seventeen taxa occur in New Zealand (Moore 1966) with three in Australia. The remaining taxa are found in Hawaii (a northerly outpost), northern Papua, New Caledonia, the Marquesas Islands, the Society Group and antarctic America, with an isolated representative in the Islands of Reunion and Mauritius (east of Africa). New Zealand is a likely centre of development and past migration.

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Australian species

The three Australian species of *Astelia* are endemic and restricted to specific habitats in the temperate south-eastern corner of the continent including Tasmania. *Astelia australiana* (subgenus *Tricella*) has a disjunct distribution in the Otway Ranges and Central Highlands of Victoria where it occupies wet, silty sites within cool temperate rainforest. The other Australian member of the subgenus *Tricella*, *A. psychrocharis*, occurs in the alpine and sub-alpine areas of Kosciusko National Park in New South Wales where it occupies Bog and tall alpine herbfield sites (Costin *et al.* 1982). The third species *A. alpina* (subgenus *Astelia*) comprises two recognised varieties and occupies similar habitats to *A. psychrocharis*. In Kosciusko National Park *A. alpina* var. *novae hollandiae* and *A. psychrocharis* are often found growing together. The former species also occurs in much of the Victorian high country. *Astelia alpina* var. *alpina* is restricted to the mountain areas of Tasmania (Costin *et al.* 1982).

Astelia australiana

Tall Astelia was first recorded in 1929 after a colony was found by J.H. Willis near Powelltown, Victoria. It was originally identified as *A. nervosa* which is found in New Zealand but was later considered to be a separate species. It is a robust, perennial herb which grows up to 2 m tall, with leaves (60-230 cm long and 4-15 cm wide) forming tufts that are connected by rhizomes. The rhizomatous habit of the species leads to the formation of colonies but makes it difficult to distinguish individual plants. Flowering of individual tufts is infrequent and seedling recruitment appears to be a minor part of the plant's reproduction. Green or reddish flowers are borne on many-flowered open panicles with individuals generally considered to be either male or female (Willis 1939; Williams 1987). Marks (1992), however, records the plants as either female or hermaphrodite and V. Turner (*pers. comm.*, Dept. of Evolutionary Biology, Monash University) considers this to be the norm for *A. australiana*.

Distribution and habitat

All known colonies of *A. australiana* are within a relatively small area in the Powelltown-Beenak area of the Central Highlands except for one colony in the Lavers Hill area of the Otway Ranges (Fig.1). The species occurs mainly in cool temperate rainforest dominated by Myrtle Beech *Nothofagus cunninghamii* with two colonies in Riparian Thicket dominated by Scented Paperbark *Melaleuca squarrosa* and Woolly Tea-tree *Leptospermum lanigerum* (Fig. 2). The ecology of *A. australiana* and the implications for management are described in detail by Turner (1991).

Decline in distribution

Whilst the distribution of *A. australiana* has probably diminished over the past 2,000-10,000 years as the climate became drier, severe reductions in colony numbers have occurred since European settlement as

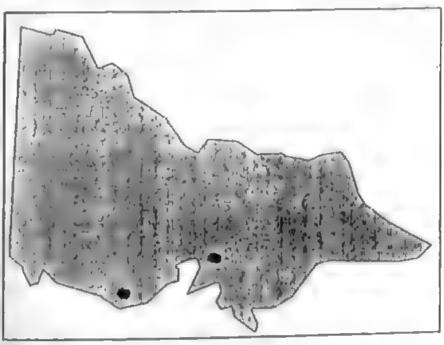

Fig. 1. Location of populations of *Astelia australiana*. (Flora Branch, Department of Conservation and Environment).

Fig. 2. *Astelia australiana* in conjunction with *Melaleuca squarrosa* at Gembrook. (*Photograph: E. James*).

a result of land clearing, logging and successive wildfires (J.H. Willis, *pers. comm.*). Early settlers reported that the plant was once common in the Yarra catchment (Parish of Beenak) but is now represented in that area by only two colonies, one of several hundred tufts and the other of a few tufts possibly derived from a single individual. An extensive population along the McCrae Creek has not been sighted since the 1939 fires and is presumed extinct (J.H. Willis, *pers. comm.*). It is thought to be sensitive to fire and may also be sensitive to the root rotting fungus *Phytophthora cinnamomi* under certain conditions.

Genetic diversity

The levels of genetic diversity in colonies of *A. australiana* are not known. There are no obvious phenotypic (morphological) differences between tufts either within or between different populations. The only observed phenotypic difference is the flower type present on inflorescences. The impact on genetic diversity, where populations are lost due to human interference or a catastrophic event, is likely to be high because the loss of variability from the population or species occurs quickly and is not related to the particular habitat in which the plant is found. *Astelia australiana* is both rare and restricted to a fairly specific habitat type. Its rarity may reflect adaptation to a habitat which has become rare through climatic change and European settlement. Inbreeding is highly likely in *A. australiana* because only a few individuals flower at the same time and nearby flowering tufts may be genetically identical.

Reproductive biology

Most information available for reproductive biology in the genus is anecdotal. A general observation is that individual tufts flower infrequently and unpredictably.

Dioecy is the occurrence, within a species, of separate plants which bear only female or only male organs. The genus is considered to contain either male or female plants according to published studies. Two sexual forms of *A. australiana* were observed but the species does not appear to be dioecious in the strict sense. The first form is female with no male function (Fig. 3) and is in keeping with the literature relating to dioecy in the genus. The second form appears to be hermaphroditic rather than male because the flowers set fruit containing seed and also produce pollen (Fig. 4). This condition is known as gynodioecy. Williams (1987) has described *A. australiana* as normally dioecious although some male plants produce a few fruits with apparently normal seeds. The occurrence of female function in male individuals is considered to be uncommon in other species of *Astelia*. Godley (1979) said that some male inflorescences in *Astelia* can carry functional hermaphrodite flowers and that male parthenocarpy (fruit production without seed) can also occur.

The ratio of hermaphrodite to female individuals in populations is unknown and can be based only on a comparison of flowering individuals but warrants further study and documentation. Pollen morphology and viability are described by Marks (1992).

A pollen vector is required for the transfer of pollen between inflorescences and between flowers on the same inflorescence but so far the vector has not been identified.

Fig. 3. Female plant of *Astelia australiana*. (*Photograph: E. James*).

Fig. 4. Hermaphrodite plant of *Astelia australiana*. (*Photograph: E. James*).

Fruitset on female inflorescences is usually very high. This may be due to a high percentage of functional ovaries and efficient pollen transfer by vector, or apomixis (seed production in the absence of pollination) may occur. Apomixis can be ruled out by sectioning ovules during development to see if embryo sacs are formed. Fruitset on hermaphroditic inflorescences is often lower compared to that on female inflorescences and may be due to some apparently hermaphrodite flowers containing non-functional ovules. Alternatively, fruit may develop in the absence of pollination but not contain fertile seeds.

Recent work on the genetic variation in *A. australiana* using DNA analysis (E. James, *unpubl.*) shows clearly that individuals from the Otways form a group which is distinct from the Central Highlands populations, yet there is still a high degree of similarity between them both. It is suggested from these results that there was originally continuous variation in *A. australiana* throughout its geographic range. The Otways population appears to be a natural occurrence and was most likely separated from plants in the Central Highlands when Basalt flow formed the western basalt plains making large areas unsuitable for *A. australiana*. The number of genetically distinct individuals in *A. australiana* colonies is not known due to the rhizomatous habit of the plant but DNA analysis has shown that there are differences in DNA between tufts which can presumably be correlated to different genotypes. The actual number of breeding individuals, however, is extremely low and probably makes up a very small percentage of the entire number of individual tufts observed in any single population within the species restricted range.

Long-term outlook for *A. australiana*

Plants of *A. australiana* appear vigorous in sites of high habitat quality. However, disturbed habitats have a high incidence of invasion by species of e.g. *Gahnia* and introduced species of *Rubus* (*R. fruticosa* complex). The outlook for the continued survival and long-term viability of *A. australiana* is positive provided that the quality of the habitat is maintained. One of the major long-term goals for the conservation of *A. australiana* should be to ensure that there is no diminution of the current level of genetic diversity so that future adaptation and successful expansion in natural populations is possible. Conservation of habitat will be the most cost-effective and suitable method of maintaining current levels of genetic diversity.

Ackowledgements

I would like to thank Adrian Moorrees, Vivienne Turner, Marita Sydes, Roger Ashburner and Jim Willis for their discussions and help with locations while I was working on *Astelia*.

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Geology of Popular Places in the Western MacDonnell Ranges, Central Australia

Dr. A.W. Beasley[1]

In recent years it has become much easier to travel further afield than in the past. Places that were once considered to be remote in the Northern Territory are now being visited by an increasing number of people. A holiday based at Alice Springs normally includes a visit to the Western MacDonnell Ranges, to the west of the town. These ranges are especially interesting for their geology, plants and their native animals. The Western MacDonnell National Park covers an area of 210,000 ha and incorporates the localities that most tourists visit (Fig. 1). It is worthwhile for field naturalists and others who visit the region to know something about its geology, as the scenery is intimately related to the geology.

The rocks seen at the localities that especially attract and impress people in the Western MacDonnell Ranges were laid down under the sea in Precambrian and Cambrian times. The Precambrian period of geological time precedes the Cambrian period, which itself dates back from 500-570 million years ago. Sedimentary rocks laid down under the sea during the Ordovician period that followed the Cambrian, also are significant components of the MacDonnell Ranges.

The Ranges are exceptionally striking when viewed from the air. The ancient sedimentary rocks occur in long, sharp ridges, or cuestas, and in gently sweeping curves. The ridges are composed generally of quartzites, formed by the metamorphism of Precambrian sandstones. The quartzites are hard and resistant to erosion.

The upheavals that produced the MacDonnell Ranges were the result of major earth movements that occurred during the Devonian period of geological time, about 350 million years ago. The ranges produced by these major upheavals were probably over 5,000 m high. Erosion over many millions of years has reduced the ranges to their present height. However, they are still impressive, rising up to 1,000 m above the surrounding plain. As well as the spectacular folding of the rocks, the steep (frequently nearly vertical) dip of the strata was produced during this ancient period of mountain-building.

Heavitree Gap, through which the Todd River flows southward after heavy rain, is on the southern outskirts of Alice Springs. The Gap separates the Western MacDonnell Ranges from the Eastern MacDonnell Ranges.

Heavitree Gap, Simpsons Gap, Ellery Creek Gorge, Serpentine Gorge and Ormiston Gorge are all gaps that have been formed by streams cutting through quartzite known geologically as the Heavitree Quartzite. This quartzite is often pinkish or brownish in colour due to staining by varying amounts of iron oxides both in and on the rock. The Heavitree Quartzite is of late Precambrian age, originating some time between 800-850 million years ago.

Simpsons Gap, about 22 km west of Alice Springs, has been formed by the erosion caused by Roe Creek (Fig. 2). The creek was once fast-flowing and the gradient of the stream quite steep, caused most probably by gradual warping or tilting of the land surface in the past. The eroding power of the fast-flowing stream over a long period of time has cut the narrow gorge through the rock. Thompson (1991) considers that the gorge probably follows a pre-existing joint (rock-fracture) trend in the quartzite.

Ellery Creek Gorge, which is located about 85 km west of Alice Springs, is best known to the public for the waterhole called the Ellery Creek Big Hole that has developed in the narrow gorge. Ellery Creek flows through the gorge and continues southwards to join the Finke River, though nowadays it is dry for most of the year. In parts of the gorge the strata are almost vertical, but on either side of the waterhole an overturned

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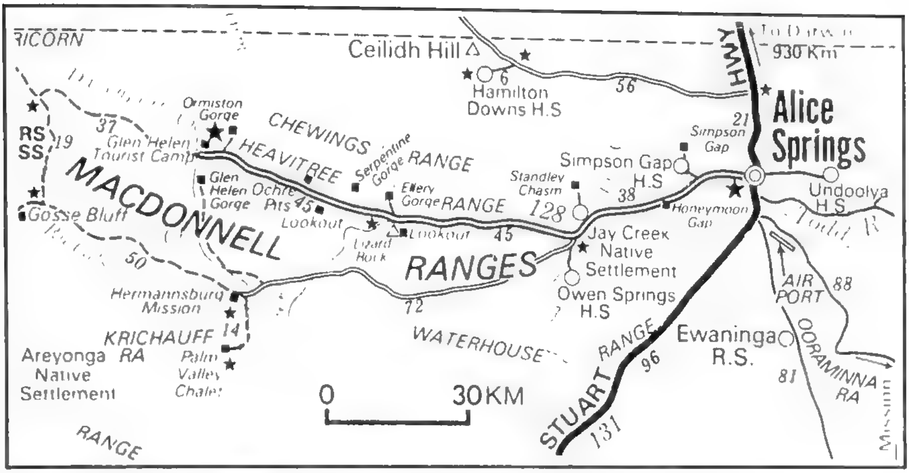

Fig. 1. Map showing location of popular places in the Western MacDonnell Ranges.

fold in the Heavitree Quartzite can be seen, produced by the intense lateral pressure that occurred during the ancient period of mountain-building. Thompson (1991) considers that Ellery Creek Gorge may lie along a north-south fault line which has slightly displaced the quartzite.

From Ellery Creek Gorge downstream for about 8 km one can see a very interesting sequence of sedimentary rocks exposed along the banks and in the bed of Ellery Creek. Indeed, a thickness of about 6,000 m of sedimentary rocks can be inspected, including sediments laid down beneath the sea during the Cambrian period, the Ordovician period and later periods of geological time. The rocks, which include sandstones, shales, limestones and conglomerates, are fossiliferous, and the various fossils found in them have been of use in dating the sediments.

Serpentine Gorge is approximately 20 km to the west of Ellery Creek Gorge. In fact, it has been formed by a stream that is a tributary of Ellery Creek. Two gorges actually occur here where the south-flowing creek cuts through two ridges of Heavitree Quartzite. There is a prominent fold in the strata between the two ridges. At the upstream site at this locality, the very narrow gap indicates that the creek has eroded along a nearly straight, vertical joint.

At Ormiston Gorge, about 24 km north-west of Serpentine Gorge, there are sheer 200 m cliffs of pinkish quartzite. The deep, narrow gorge has been eroded by Ormiston Creek, a tributary of the Finke River. The geology here is very complex with much folding and overthrusting of the rock strata.

Glen Helen Gorge has been eroded by the Finke River through a sandstone of Cambrian age known as the Pacoota Sandstone. The shape of the Gorge has been controlled quite markedly by jointing in the rock, the joints (parting-planes) having acted as zones of weakness to erosional forces. The layers of sandstone that were originally horizontal have been turned up on end during the upheavals that produced the MacDonnell Ranges. This popular place is approximately 125 km west of Alice Springs.

Standley Chasm is a narrow chasm which has been formed by erosion in quartzite known geologically as the Chewings Range Quartzite (Fig. 3). This quartzite is of early Precambrian age and is probably about 2,000 million years old. A vertical dyke of an igneous rock called dolerite here was intruded into Chewings Range Quartzite. Dolerite is much less resistant to weathering and erosion than quartzite and a south-flowing creek has almost completely eroded away this dolerite dyke leaving vertical quartzite walls; this is now Standley Chasm. The relatively narrow, parallel-sided ig-

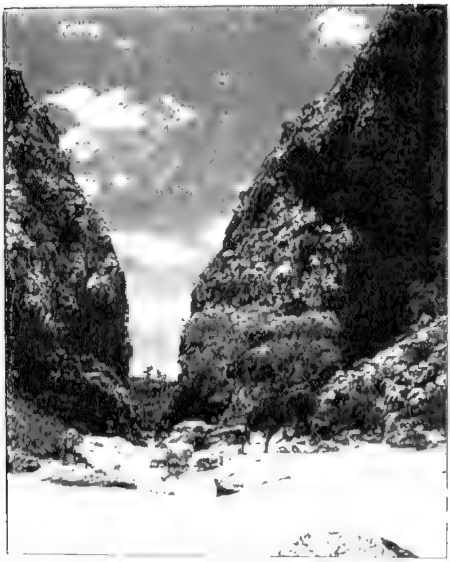

Fig. 2. Simpsons Gap. A gap cut through quartzite, Western MacDonnell Ranges, 22 km west of Alice Springs.

neous intrusion was one of the dolerite dykes of the Stuart Dyke Swarm, which according to Black *et al.* (1980) intruded the older Chewings Range Quartzite about 897 million years ago. The intrusion of the molten igneous rock opened up fractures in the quartzite.

These rock-fractures and major joint planes in the quartzite, resulting from other causes, have facilitated erosion contributing to the formation of Standley Chasm. The Chasm is at its most dramatic at midday when the sun briefly paints both walls a brilliant orange. This spectacular gorge is some 45 km west of Alice Springs.

All these scenic attractions in the Western MacDonnell Ranges are easily accessible from Namatjira Drive, the name given to the sealed bitumen road that links Alice Springs and the Glen Helen settlement. At Glen Helen there are restaurant and accommodation facilities.

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Fig. 3. Standley Chasm. A narrow gorge with very steep walls of quartzite, 45 km west of Alice Springs.

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Whipstick Nature Trail

R.J. Fletcher[1]

An article with this title was published by F. Robbins in *The Victorian Naturalist* **85** 1968, 225-227. Reference is also made to a 1966 FNCV 'Whipstick Excursion' in 1966 (*The Victorian Naturalist* **84** 1967, 50-53). The 1968 article was meant as a self-guided tour through a section of the Whipstick, while the latter is a report of a field trip and is basically a plant list.

An opportunity arose in early October 1994 to retrace the route described as 'The Nature Trail', although this was later than the original August date recommended by F. Robbins. His purpose was to draw particular attention to what he called the Hakea Wattle but which is known in this area as Whirrakee Wattle *Acacia williamsonii* (*A. williamsonii* A.B. Court formerly *A hakeoides* A.Cunn ex Benth and referred to as *A. hakeoides* var. *angustifolia* in 'Flowers and Plants of Victoria' by Coxhrane, Fuhrer *et al.* 1968), which makes such a display at that time. This shrub, featured in the original article, is still abundant although, in one instance where he mentions a 'paddock full', there has been some modification. A few late-flowering specimens of *A. williamsonii* were seen, especially near the old location of Magetti's wine saloon.

The 1994 season has been particularly dry and where Robbins mentions water and fords there are neither. Fords have been replaced by culverts and some alterations have been made in road and track re-alignment. This is the main reason for some difference in mileage noted in Table 1. The sketch map, based on that of Robbins, shows the route beginning and ending at the fountain in Bendigo and the distances referred to in Table 1 are based on this route.

After leaving the Midland Highway, just before the old Council Chambers at Huntly, the first point of significance is at what Robbins referred to as 'the paddock full of *A. hakeoides*'. The paddock is still there with an intriguing sign that reads:

"Do not curse this old gate,
You may be old and stubborn
and hard to shift yourself one day".

There are some remnants of the wattle in the paddock and a few trees such as Yellow Gum *Eucalyptus leucoxylon* and Grey Box *E. microcarpa* but it has obviously been heavily grazed for many years. However, there is a very good roadside remnant that shows some of its former glory. (List 1)

List 1. Millwood Road, roadside verge

Spreading Wattle	*Acacia genistifolia*
Whirrakee Wattle	*Acacia williamsonii*
Cranberry Heath	*Astroloma humifusum*
Everlasting Daisies	*Bracteantha* sp.
Black-anther Flax-lily	*Dianella revoluta*
Yellow Gum	*Eucalyptus leucoxylon*
Grey Box	*Eucalyptus microcarpa*
Leafless Currant-bush	*Leptomeria aphylla*

Along Goodings Road from the sign indicating Neilborough, the roadside verge is worth a few stops. At the sweeping curve in the new bitumen road there is also a large sign indicating the Whipstick State Park. Robbins mentions that, at this point, there are all sorts of interesting things to see in the paddock on your right. This is no longer the case. It also has been cleared and heavily grazed over the intervening years.

Just a little further on is a roadside picnic area which indicates the start of Loeser Road. In spite of the extreme dryness of the season, many plants were observed although some were showing signs of distress. List 2 is by no means exhaustive but indicates some of the flora in the understorey of this area.

Between this picnic area and the one at the site of the former Eucalyptus Distillery, now known as the Loeser Picnic Area, there are many places to stop and look. All that remains of the distillery is the boiler. It is less than a kilometre from here to the intersection with Skylark Road, and, especially along this section, the traveller needs to take time.

[1]4/48 Newport Road, Clayton South, Victoria 3169.

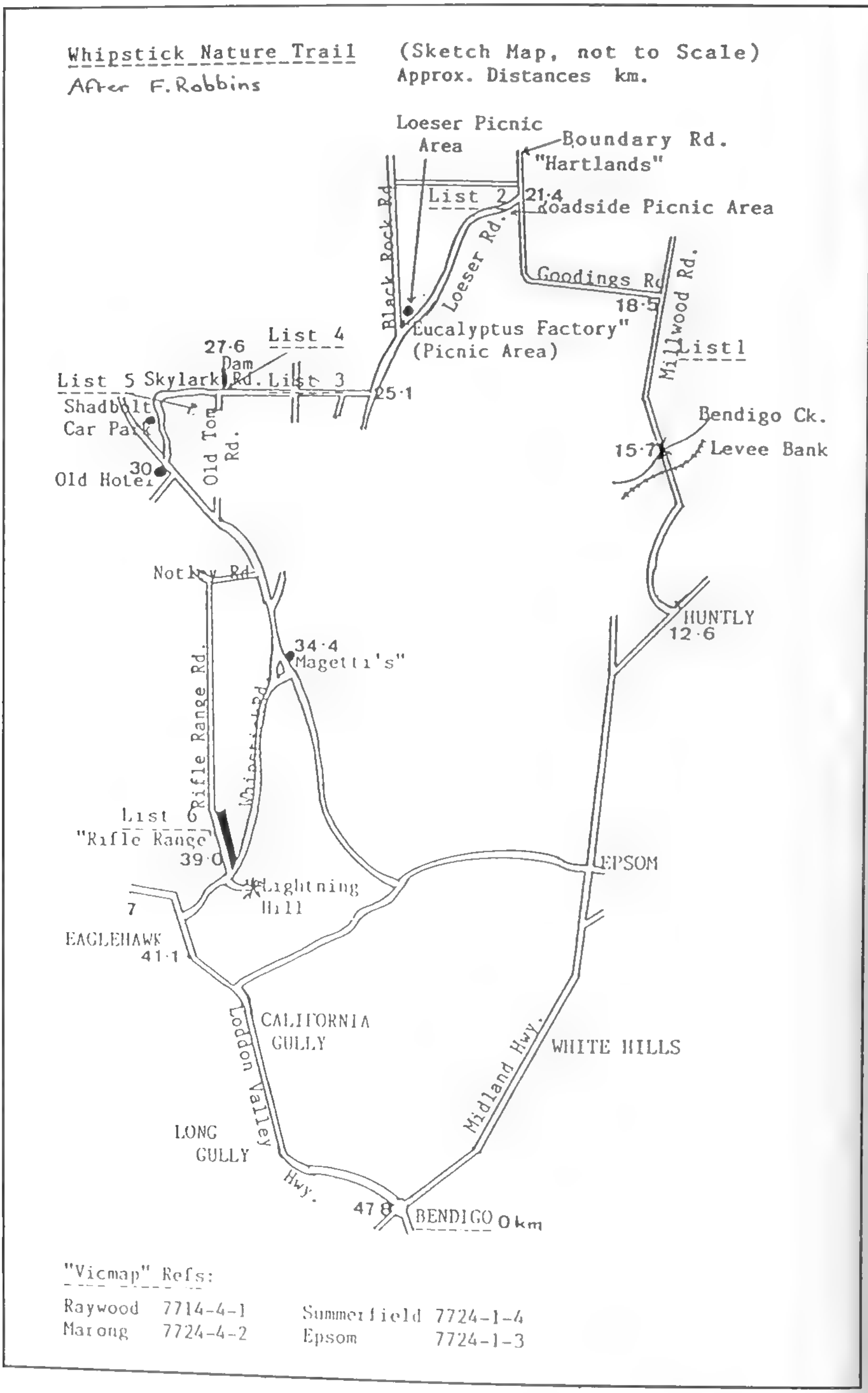
Whipstick Nature Trail
After F. Robbins
(Sketch Map, not to Scale)
Approx. Distances km.
Loeser Picnic Area
Boundary Rd.
"Hartlands"
List 2
21·4
Roadside Picnic Area
Black Rock Rd.
Loeser Rd.
Goodings Rd
18·5
Millwood Rd.
"Eucalyptus Factory"
(Picnic Area)
List 4
27·6
Dam Rd.
List 5
Skylark Rd.
List 3
25·1
List 1
Shadbolt Car Park
Old Tom Rd.
Bendigo Ck.
15·7
Levee Bank
30
Old Hotel
Notley Rd
HUNTLY
12·6
34·4
"Magetti's"
Rifle Range Rd.
Whipstick Rd.
List 6
"Rifle Range"
39·0
Lightning Hill
EPSOM
7
EAGLEHAWK
41·1
CALIFORNIA GULLY
Loddon Valley Hwy.
Midland Hwy.
WHITE HILLS
LONG GULLY
47·8
BENDIGO 0 km
"Vicmap" Refs:
Raywood 7714-4-1
Marong 7724-4-2
Summerfield 7724-1-4
Epsom 7724-1-3

Table 1. Whipstick Nature Trail. Basic comparison of distances with that of F. Robbins in 1968 (some differences may be accounted for by road changes).

Feature	Distance			Observation
Bitumen	FR (ml)	FR (km)	RJF (km)	
Fountain	0.0	0.0	0.0	The excursion described by Robbins began and ended at the fountain at the entrance to Bendigo from the Calder Highway
Huntly	7.8	12.6	12.6	
Bridge (Bendigo Creek)	9.7	15.6	15.7	
Ford	10.8	17.4	17.4	Now a culvert, the bitumen continues
Paddock	11.2	18.0	18.2	Largely cleared and grazed but stand of *Acacia williamsonii* on roadside verge. (See list 1)
Neilborough turnoff	11.5	18.5	18.5	
			18.7	Stand of *Exocarpus* sp
	12.0	19.3	19.3	*Acacia williamsonii* in paddock and on verge
Road turns to right	12.6	20.3	20.1	New bitumen road at beginning of Whipstick State Park. Paddock on right grazed out
Graded track				
Loeser Rd				
Picnic Area	13.4	21.6	21.4	In spite of extremely dry conditions, *Caladenia carnea* and *Westringia eremicola* were seen. (see list 2)
Eucalyptus Factory	15.3	24.6	24.4	All that remains is a boiler and a dam the area is now a picnic ground
Ford	15.6	25.1	24.9	What was a ford, 'never dry', is now a dry culvert
Fence	15.8	25.4	25.1	Still remains of a fence. This is the intersection of Skylark and Loeser Roads
	16.0	25.8	25.6	Green flowered *Grevillea rosmarinifolia* and extensive colony of *Caladenia carnea* (see list 3)
Skylark Dam	16.5	26.7	27.6	Rich flora area, also still favoured by gold? prospectors (see list 4)
Stony Rise	17.7	28.5	28.1	'Flagstaff Reservation', a long-since abandoned project (see list 5)
			28.3	*Pseudanthus ovalifolius*
Sebastian Water Race	18.4	29.6	29.1	*Phebalium obcordatum*. Shadbolt Picnic Area carpark. Old Tom Mine Walk
Old Hotel	19.0	30.6	30.0	Old Lamp still complete
			32.8	Turn-off to Notley Picnic Area, an alternative route to Rifle Range Road
Bitumen				
Whipstick Road	21.7	34.9	34.2	The main road to Eaglehawk
Magetti's			34.4	All that remains are a few bricks and 3 Peppercorn Trees. Road to right rejoins Whipstick Rd
Rifle Range	24.6	39.6	39.0	Except for 'Hill Behind', the range is almost completely overgrown (see list 6)
Lightning Hill	24.9	40.1	39.3	Lookout, directional plaque missing
Eaglehawk	26.0	41.9	41.1	Town Hall and Old Log Jail
Bendigo Fountain	31.0	50.0	47.8	Distance on current roads and tracks varies from point to point with those of 1968, but in total only 2.2 km

List 2. Boundary Road, at Loeser Road intersection

Pink Fingers	*Caladenia carnea* var. *carnea*
Common Correa	*Correa reflexa*
Blue Dampiera	*Dampiera lanceolata*
Red Ironbark	*Eucalyptus sideroxylon*
Hop Goodenia	*Goodenia ovata*
Totem-poles	*Melaleuca decussata*
Cyprus Daisy-bush	*Olearia teretifolia*
Slender Westringia	*Westringia eremicola*

This is typical 'Whipstick' scrub and a foray to the right or left at almost any point will be rewarded. List 3 details a few of the plants to be seen.

List 3. Along Skylark Road

Gold Dust Wattle	*Acacia acinacea*
Varnish Wattle	*A. verniciflua*
Daphne Heath	*Brachyloma daphnoides*
Pink Fingers	*Caladenia carnea* var. *carnea*
Coarse Dodder-laurel	*Cassytha melantha*
Hop Bush	*Dodonaea cuneata*
Bull Mallee	*Eucalyptus behriana*
Blue Mallee	*E. polybractea*
Green Mallee	*E. viridis*
Mountain Grevillea	*Grevillea alpina*
Rosemary Grevillea	*G. rosmarinifolia*

The area around Skylark Dam is particularly rich in interesting plants even though there has been, and still is, digging and fossicking carried on. Both the Blue Mallee *Eucalyptus polybractea* and Green Mallee *E. viridis* have also been cut for the eucalyptus distillery in the past but it is well worth spending time here. There is ample room to park just before the dam is reached and List 4 indicates some of the plants you might see.

List 4. Skylark Dam and nearby area

Rough Wattle	*Acacia aspera*
Daphne Heath	*Brachyloma daphnoides*
Musky Caladenia	*Caladenia gracilis*
Drooping Cassinia	*Cassinia arcuata*
Gorse Bitter-pea	*Daviesia ulicifolia*
Red Box	*Eucalyptus polyanthemos*
Red Ironbark	*Eucalyptus sideroxylon*
Green Mallee	*Eucalyptus viridis*
Wax-lip Orchid	*Glossodia major*
Rosemary Grevillea	*Grevillea rosmarinifolia* (red & green forms)
Silky Hakea	*Hakea* sp.
Leafless Currant-bush	*Leptomeria aphylla*
Red Beard-heath	*Leucopogon rufus*
Totem-poles	*Melaleuca decussata*
Dainty Phebalium	*Phebalium obcordatum*
Rough Mint-bush	*Prostanthera denticulata*
Matted Bush-pea	*Pultenaea pedunculata*

Robbins speaks of a reservation to the south of a 'stony rise' nearly 2 km further on from the dam. In fact this is about 0.5 km along Skylark Road and what remains of the reservation may still be seen, if you walk through the area that has been cut for the distillery, and the stand of *Melaleuca decussata*. This reservation was established by Frank Robbins and members of the Bendigo Field Naturalists Club in an attempt to preserve rarer species of flora, but is apparently not familiar to the current generation of Field Naturalists in the area. It has apparently been long since abandoned and the fence is in a state of disrepair (see *The Victorian Naturalist* **84** 1967, 52). A few plants still have name tags painted in black enamel on pieces of galvanised iron, but the area, about 200 m x 50 m, could hardly be called the 'Flagstaff Reservation' any longer. List 5 indicates a few of the plants to be found here.

At 28.3 km, just where Skylark Road leaves the Whipstick vegetation and enters a mainly Ironbark area, it is worthwhile to pull off the road and wander for a while.

List 5. 'Flagstaff Reservation', south of Skylark Road

Small Crowea	*Crowea exalata*
Eucalypts	*Eucalyptus* spp.
Golden Pennants	*Glischrocaryon behrii*
Clasping Goodenia	*Goodenia amplexans*
Leafless Currant-bush	*Leptomeria aphylla*
Heath-myrtle (pink flowers, prostrate)	*Micromyrtus ciliata*
Dainty Phebalium	*Phebalium obcordatum*
Rough Mint Bush	*Prostanthera denticulata*
Oval-leaf Pseudanthus	*Pseudanthus ovalifolius*

Among the many smaller plants to be seen is *Pseudanthus ovalifolius*, growing in anything but the 'usually sandy ground' mentioned by Willis (Willis, 'Handbook to Plants in Victoria' Vol II, 351).

When you reach the Shadbolt Picnic Area carpark, time out could be taken for a walk to the Old Tom Mine. What Robbins referred to as the 'Sebastian Water Race' is now marked on the map as Raywood Channel. Shortly after this point the Eaglehawk-Neilborough Road is rejoined and the old hotel with its lamp still intact, is reached. A little less than 3 km further on is the turn-off to the Notley Picnic Area which, along with the Shadboldt Area, is the site of a former eucalyptus distillery.

There are plenty of reasons to botanise on the left-hand side of the road along here, as there are along the Whipstick Road which is clearly signposted. Just past the commencement of the Whipstick Road is the site of the former Magetti's Wine Saloon which was apparently the venue for some roistering times in the old days. Nothing now remains but an old Peppercorn tree **Schinus molle* and what must be two of its descendants together with a few broken bricks.

Just past this point you can rejoin the Whipstick Road and at about 39 km link up with the intersection of Rifle Range Road. The sign is not very visible when coming from the north, so if you come to the turnoff to the Lightning Hill Lookout, you have gone too far.

List 6. 'Rifle Range' on Rifle Range Road

Gold-dust Wattle	*Acacia acinacea*
Rough Wattle	*A. aspera*
Spreading Wattle	*A. genistifolia*
Golden Wattle	*A. pycnantha*
Varnish Wattle	*A. verniciflua*
Drooping Mistletoe	*Amyema pendulum*
Cranberry Heath	*Astroloma humifusum*
Rosy Baeckea	*Baeckea ramosissima* (pink and white forms)
Daphne Heath	*Brachyloma daphnoides*
Everlasting Daisy	*Bracteantha* sp.
Common Fringe-myrtle	*Calytrix tetragona*
Drooping Cassinia	*Cassinia arcuata*
Coarse Dodder-laurel	*Cassytha melantha*
Common Correa	*Correa reflexa*
Bitter-pea	*Daviesia leptophylla*
Gorse Bitter-pea	*D. ulicifolia*
Black-anther Flax-lily	*Dianella revoluta*
Fairy Wax-flower	*Eriostemon verrucosus*
Red Box	*Eucalyptus polyanthemos*
Red Ironbark	*E. sideroxylon*
Cherry Ballart	*Exocarpus cupressiformis*
Wax-lip Orchid	*Glossodia major*
Goodenia	*Goodenia* sp.
Mountain Grevillea	*Grevillea alpina*
Silky Hakea	*Hakea* sp.
Guinea-flower	*Hibbertia* sp.
Leafless Currant-bush	*Leptomeria aphylla*
Beard-heath	*Leucopogon rufus*
Lomandra	*Lomandra* sp.
Totem-poles	*Melaleuca decussata*
Yam Daisy	*Microseris lanceolata*
Slender Rice-flower	*Pimelea linifolia*
Apple-berry	*Rhytidosporum procumbens*
Feather Spear-grass	*Stipa elegantissima*
Pink Bells	*Tetratheca ciliata*

You will need time in this area. It is many years since this was used as a rifle range and, apart from the 'hill behind', there is little evidence of such a function. This is emphasised by the sign which announces "No Shooting"! The regrowth is very interesting and would no doubt require more than one visit for a complete listing. List 6 names the plants seen in one traverse.

It is worth a short diversion to the Lightning Hill Lookout for an overview of the whole area. Unfortunately, as in so many instances, the plaque which once pointed out landmarks is missing. Just below the Lookout you rejoin the bitumen on the outskirts of Eaglehawk and the circuit may be completed by returning to the fountain in Bendigo.

In Frank Robbins' article of 1968, observation of *Acacia hakeoides* was its main theme, but it is quite apparent that the Whipstick will repay a visit at seasons other than late winter.

*exotic plant

From our Naturalist in Residence, Cecily Falkingham

Those Amazing Mistletoe Plants

This plant's very beginnings are sheer magic and its survival in the early stages is an incredible story. This amazing plant occurs in mangroves, jungles, deserts, dry and wet sclerophyll forests, mallee, heathland etc. and it is time its public image was lifted.

Mistletoe plants were long recognised by Koori people as a useful food source. Especially the sticky fruits of the *Amyema* species which were eaten raw. The pulp is sweet and the leaves were also used for medicinal purposes.

Fires lit by Aboriginal people all over this country would have effected some control over this fire-sensitive plant. On the other hand, an increase of Mistletoe has probably occurred with the altered landscape and fire regime that has developed with European settlement and as a result Mistletoe is now considered by some to be a problem plant.

The majority of people I speak to, talk with concern about its required removal and I have witnessed large-scale vandalism in bushland reserves and on private property. Trees with only minor outbreaks of Mistletoe have suffered rigorous pruning and complete removal of the Mistletoe plant. This with little regard or knowledge for the food and shelter this marvellous plant provides. According to the literature a tree needs to be infected by at least 20-30% to be in danger of becoming moisture stressed and possibly dying. Most people seem to lose sight of the fact that this green semi-parasitic plant does photosynthesise.

Uses

The twelve species of Mistletoe we have in Victoria provide nectar for animals over a long period; for example the flowering season of *Amyema pendulum* sometimes stretches from May until the following summer. The flowering of various Mistletoes covers most months of the year and would be vital for animals in search of nectar in winter when little else may be flowering.

Many animals use the bushy, thick and pendulous leaf masses on mature plants for shelter. I have observed many birds' nests and possums' dreys hidden in their voluminous foliage and seen many birds feeding and sheltering in Mistletoe plants. In fact, it has become an interest of mine when I discover Mistletoe to search for signs of its many uses by our local fauna.

The large colonies of Imperial White butterflies alone must be an important food source. (With two generations per year often containing sixty or seventy larvae to one web this must surely be one of the natural controls of Mistletoe). Wood White, Common Jezabel and Imperial White butterflies both larvae and adults may contribute considerably to the food source of many animals especially birds.

Last year I rescued approximately 40 Imperial White butterfly larvae and pupae cases from the ground where they lay. Some were crushed and were injured and some of them were already dead. The large branch under which they lay had been cut down from a Eucalypt which had been sawn off and left where it fell. Perhaps the property owner mistook the dark larvae for sawfly larvae. This animal also suffers from a poor public image and again without just cause. But both Mistletoe and the insects obviously were not wanted and both were ALMOST destroyed. I did manage to raise and save more than half of the butterflies which were released into local bushland within metres of the site where I found them.

Land Clearance

Over the years I have observed heavier infestations on solitary trees on partially cleared land, and also a greater incidence of Mistletoe along roadsides. Opening the canopy, and more light as a consequence may favour the plant. Roadsides are often good flight paths for birds that spread the seed i.e. Mistletoe Birds and Painted Honeyeaters.

To test the roadside theory I have on many occasions explored further into good quality bushland DIRECTLY behind heavy infestations and on all occasions fewer occurrences of the plant is observed.

Over a period of nearly two decades of fascination and observation of this plant I have come to this conclusion, that we should be providing educational leaflets for property owners (urban and rural) which contain sensible guidelines on how to appreciate and/or control Mistletoe.

As naturalists and scientists we need to inform the media in its many forms that this plant is a natural and fascinating component of our native flora and vital to the lives of many animals including birds. It is an important source of food and shelter and essential for the survival of several species of some of our most beautiful butterflies.

Apart from all those reasons it is a plant that we could learn a lot more about so that we can support and nurture its growth and at the same time develop SENSIBLE management strategies.

Cecily Falkingham
27 Chippewa Ave, Mitcham, Victoria

Australian Defence Force Academy

The Literature of Australian Natural History

A One Day Seminar about Writers and Writings on the Animals and Plants of Australia

This one-day seminar will be held in Canberra on Friday, 8 December 1995.

The topics discussed will include both the writing itself - scientific, literary, popular - and the writers, from Joseph Banks to Densey Clyne.

The seminar will provide a forum for writers and scientists, as well as students and amateur naturalists, to contribute and listen to modern debate on literary and historical aspects of Australian natural history writing, and just as importantly to share knowledge and interests with others.

Registration forms will be sent out in early May, 1995.

Please send enquiries and proposals for papers to:

Nick Drayson, English Department, University College, Australian Defence Force Academy, Canberra, ACT 2600.

Tel: (06) 268 8433; Fax: (06) 268 8899; e-mail: nick-drayson @ adfa.oz.au

Geology

Jack Douglas[1]

Many Field Naturalist Club members will have an interest in geology. After all, the earth itself is an integral part of the environment, encompassing all the manifestations of nature. If you want to upgrade your expertise in geology (and this may well be from a most minimal base) you would achieve this most quickly by participating in the activities of the FNCV section called the Geology Group.

Activities

Regular monthly addresses on aspects of the earth sciences, with subject and speaker notified in the Club newsleter;

Submission and discussion of specimens and items of interest at these meetings;

Field inspections and excursions under the guidance of leader/s with pertinent expertise;

Preparation and production of publications on aspects of Victorian earth science;

Preparation of exhibits for Club displays or other organisations as requested, and providing personal explanation where feasible;

Initiation and development of specific projects from time to time;

Interaction with other FNCV groups and other groups interested in geology.

Your choice

As with bird watching, (see December 1994 volume 111) there is plenty of scope for specialisation. Some become fascinated with the record of life in the rocks, that is PALAEONTOLOGY (often with further specialisation, perhaps becoming dinosaur hunters, or trilobite excavators, or investigators of forests of the past). Some may be intrigued with SEDIMENTOLOGY and examine the depositional patterns of age-old sandstones. ***YOU*** might acquire an outstanding knowledge of METEORITES and TECTITES.

Equipment

Equipment may well be minimal. A ***geological hammer*** with either pick or chisel end is essential for collectors, and a ***hand lens*** or good magnifying glass is vital in many circumstances. If you are loaded with money you would have a ***Magellan (GPS)*** instrument signalling satellites and pinpointing your location in off-the-track situations, but most of us are content with the ***1: 25,000 topographic maps*** easily obtained at the government map shop. A simple ***compass*** and ***clino-rule*** for the measurement of the attitude of the rocks (dip and strike) is necessary if you wish to map the strata and its subsurface projection, and other refinements such as a ***polaroid camera*** with 'instant' photos can help, but on many trips the hammer and ***notebook*** are the only essentials. There is plenty of scope for the desk-bound enthusiasts. Your ***personal computer*** is as comfortable analysing fossil distributions as storing your tax figures.

Further reading (specifically about Victoria)

'Geology of Victoria'. (Geological Society of Australia Incorp.) Comprehensive but a little daunting for the amateur.

'Introducing Victorian Geology'. (Geological Society of Australia .) A must!

'The Physiography of Victoria' by E. S. Hills. Guide to landforms.

'What Fossil Plant is That?' by J. G. Douglas. A guide to Victoria's ancient floras published by FNCV.

Enquiries

Your FNCV contact for the Geology Group is Doug Harper. You can contact him on (03) 9890 0913, or write to 33 Victoria Crescent, Mont Albert 3127.

[1] 42 Sunhill Rd, Mt Waverley, Victoria 3149.

Peninsula Plants: A Field Guide to Indigenous Plants of the Mornington Peninsula with Notes on Cultivation

by Kathie and Peter Strickland

Publisher: *Kareelah, Balnarring.*

Vol. 1, 1992; Vol. 2, 1994; each approx. 200 pages. RRP $14.95

With the urgent need to halt the clearing of native vegetation and to revegetate degraded areas with indigenous species, it is essential that we have accurate, accessible and informative literature to give sound guidance to people who want to take positive action, but who may not have formal environmental training.

In their two volumes of Peninsula Plants, Kathie and Peter Strickland have made a valuable contribution, not only for residents of the Mornington Peninsula, but also for people with similar concerns in other Victorian coast-to-foothill areas where most of the species described also occur naturally.

The original volume was put out as a self-published book in 1992 (the Stricklands operate Kareelah Bush Nursery). Because of its success, a second volume was published in December 1994.

Each volume describes about a hundred species of trees, shrubs, creepers and small herbaceous plants, covering the most common and cultivatable of the Peninsula's 600-odd species.

Each species has an accurately written full page description by Kathie, with interesting comments on history and nomenclature and practical advice on cultivation. On every opposing page are clear and mostly natural-size line illustrations by Peter, whose background as an artist is obvious. Diagnostic features are given special attention, with enlargement where appropriate.

The plants in each volume are grouped: trees, shrubs over 2 m, shrubs under 2 m, creepers, herbs, tufted herbs and orchids. Glossaries and bibliographies are included.

I did find a couple of difficulties in using the two books. An initial uncertainty arises because the second volume developed as something of an 'add-on' to the original one in terms of plant coverage, and there is no obvious basis for determining which plants are in which volume.

My second concern relates to the organisation within each book. Plants are described in botanical species-name order within each of the seven habit groups (which, apart from the reference in the table of contents, are not separated or headed in any way), yet the prominent heading for each species page is the common name in bold capitals. The effect of this is to give an initial impression of 'randomness' of order and, indeed, similar or related plants (e.g. in the several genera of the pea-flowers, Fabaceae) tend to be scattered through each book. While the habit groupings are useful, I feel that subgroupings within these by family would have helped to bring similar plants together for comparison in identification. Clear identification of the seven sections and the use of running-heads would also have given the books a more organised feel.

These concerns aside, I certainly recommend these two books for their clarity and accuracy of content, practical usefulness and, at $14.95 each, inexpensiveness compared with some botanical publications we have seen of late.

Leon Costermans

6 St Johns Ave, Frankston, Victoria 3199.

Identification Handbook for Native Grasses in Victoria

by Meredith Mitchell

Available from: *Meredith Mitchell, Rutherglen Research Institute, RMB 1145, Rutherglen, Victoria 3685*

This is a curious little booklet (34 pages) that, on the one hand, is simple in text and layout to encourage complete novices (the target audience are farmers) to identify the native grasses of their area and to alert them to the potential agricultural values of these species, whilst, on the other hand, is detailed enough at the minutiae of important grass characteristics that it serves as a very important companion introduction to students, naturalists, etc. wishing to learn to identify native grasses, an area of taxonomy perceived to be difficult.

Of Victoria's 64 genera of native grasses, ten are covered by this booklet. The booklet can hardly therefore be described as an identification handbook to Victoria's native grasses. At best, it is a simple introduction. The agronomic slant is obvious from the outset as no *Poa* species are included, it being widely recognised that these species are not favoured by grazing stock. The inclusion of a species such as *Dichanthium sericeum* is also interesting given the limited distribution of this species.

Each species is described according to general appearance and its distinguishing features. The now ubiquitous distribution map is also included. Agronomic values such as production (t/ha), forage value, crude protein content, digestibility and response to fertility are included. These data rely heavily on the research of Wal Whalley and co-workers from the north-west slopes of NSW. Whether such data can be applied to northern and southern Victoria is uncertain. Certainly, the production of 8.3 t/ha cited for *Themeda triandra* is much higher than most values recorded for Victorian grasslands other than in rank, long-unburnt stands.

What makes this booklet one of the better introductions to native grasses I have seen is John Schnieder's superb photography of often difficult subject matter. Each of the ten genera described is accompanied by six photographs. These usually include (with great clarity but unfortunately no scale) the most important diagnostic feature of native grasses including: whole plant view, leaf blade, leaf tip, leaf sheath, stem node, ligule, seedhead and seed. Whilst you will not be able to identify a genus to species level with this booklet, it may help you to improve general character recognition and build confidence in identifying native grasses.

There is also a useful identification table at the rear of the booklet to distinguish the genera covered when in a non-flowering, vegetative state. A glossary and a diagram of the generalised anatomy of a grass round off the booklet, although I suspect that these would have been better placed at the front rather than the back of the publication.

Despite some of the minor failings of this booklet, it is an important piece of work. It makes native grasses more accessible to those people who do not speak the taxonomic language. Hopefully, it will also foster enthusiasm amongst the farming community to view native grasses in a different light (our light?)

John Morgan
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Census of the Vascular Plants of Victoria Update Bulletin No. 4.4

Compiled by T.J. Entwisle[1]

Update bulletins to *A Census of the Vascular Plants of Victoria* are published in *The Victorian Naturalist* at intervals depending on the number of additions and alterations to the *Census*. The first update to appear in *The Victorian Naturalist* (111(4): 154-159) was number 4.3. The number refers to the edition of the *Census* (currently edition four) and to the number of update bulletins produced since that edition (this is the fourth).

Monocotyledons

CYPERACEAE

Descriptions, illustrations, distributions and keys to these species of Cyperaceae can be found in *Flora of Victoria*, volume 2, pp. 238-356.

Baumea planifolia (Benth.) K.L. Wilson, *Telopea* 5: 589 (1994).

New name for *Baumea* sp. (Wallaby Creek).

Chorizandra australis K.L. Wilson, *Telopea* 5: 594 (1994).

New record for Victoria.

Eleocharis macbarronii K.L. Wilson, *Telopea* 5: 599 (1994).

New name for *Eleocharis* sp. aff. *atricha* (Mt Arapiles).

Isolepis gaudichaudiana Kunth, *Enum. Pl.* 2: 201 (1837).

New record for Victoria.

Schoenus lepidosperma (F. Muell.) K.L. Wilson, *Telopea* 5: 619 (1994) ssp. **lepidosperma**.

New name for *Schoenus tenuissimus*.

Schoenus lepidosperma ssp. **pachylepis** (S.T. Blake) K.L. Wilson, *Telopea* 5: 619 (1994).

New record for Victoria.

Uncinia nemoralis K.L. Wilson, *Telopea* 5: 620 (1994).

New name for *Uncinia* sp. aff. *rupestris*.

Uncinia sulcata K.L. Wilson, *Telopea* 5: 620 (1994).

New name for *Uncinia* sp. aff. *compacta*.

LILIACEAE

Dianella amoena G.W. Carr & P.F. Horsfall, *Muelleria* 8: 369 (1995).

New record for Victoria. Restricted to grassland and grassy woodland in Victoria and Tasmania, and characterized by its long, very slender, wiry and much-branched rhizomes; the narrow, tapering and thin lax or stiff leaves that can be summer deciduous; the often small, relatively few-flowered panicles; and the large, showy stamens (with bright orange swelling).

Dianella brevicaulis (Ostenf.) G.W. Carr & P.F. Horsfall, *Muelleria* 8: 375 (1995).

New name for *Dianella revoluta* var. *brevicaulis*. This taxon is considered by the authors to be distinct at species level.

Dianella callicarpa G.W. Carr & P.F. Horsfall, *Muelleria* 8: 366 (1995).

New record for Victoria. Known from scattered, small populations in south-western Victoria, and from the Mornington Penninsula and Dandenong Ranges, but possibly more widespead (perhaps into South Australia). This species is characterized by having aerial stems; very long, lorate, strongly occluded, thin leaves which frequently arch or bend down; and flowers like *D. caerulea* var. *caerulea*.

Dianella porracea (R.Henderson) P.F. Horsfall & G.W. Carr, *Muelleria* 8: 375 (1995).

New name for *Dianella longifolia* var. *porracea*. This taxon is considered by the authors to be distinct at species level.

Dianella tarda G.W. Carr & P.F. Horsfall, *Muelleria* 8: 372 (1995).

New record for Victoria. A fragmented distribution on the northern plains of Victoria, probably extending into New South Wales. Similar to *D. longifolia* var. *longifolia* and *D. porracea*, but robust,

[1]National Herbarium of Victoria, Royal Botanic Gardens Melbourne, Birdwood Ave, South Yarra, Victoria 3141.

evergreen and densely tussock-forming; with narrow, more or less smooth, erect, moderately glaucous, deeply channelled, more or less fleshy leaves; and usually tall, more or less obovoid to elliptic (in outline) inflorescence of sprawling, elongated panicles.

POACEAE

Aristida jerichoensis (Domin) Henrard var. **subspinulifera** Henrard, *Meded. Herb. Leiden* 58A: 300 (1932).

New record for Victoria. Collected once (in 1994) from a sandy rise in yellow gum woodland near Charlton. This locally rare grass differs from other Victorian species of *Aristida* in having lemmas each with a ventral furrow that is pronouncedly tuberculate at the margin.

Rytidosperma oreophilum H.P. Linder & N.G. Walsh, *Muelleria* 8: 283 (1995).

New record for Victoria. Somewhat intermediate between *Rytidosperma erianthum* and *R. tenuis* (previously *Danthonia eriantha* and *D. tenuior*) but differing from *R. eriantha* in the setae on the lateral lobes of the lemma being much shorter than the flattened part of the lobes, always included within the glumes, the lemma often with scattered hairs between the two rows of hair-tufts, and the more compact ovate inflorescence. From *R. tenuis* it differs in having a broader, obovate palea that is glabrous abaxially, and by the compact ovate (cf. linear) inflorescence. *Rytidosperma oreophilum* grows in grassland, open heathland or on rock outcrops along the Great Dividing Range and nearby mountains from near Canberra to just north of Heyfield in Victoria.

Note that following a worldwide revision, all Victorian species of *Danthonia* except *D. lepidopoda* are now referred to *Rytidosperma.* Appropriate combinations for all Victorian species exist in *Rytidosperma* (and these may be found listed in synonymy in the *Flora of Victoria*, volume 2). Danthonia lepidopoda and Chionochloa pallida are probably congeneric but any taxonomic change must await a complete assessment of the tribe Arundineae in Australia.

Dicotyledons

ASTERACEAE

Picris angustifolia DC. ssp. **merxmuelleri** Lack & S. Holzapfel, *Wildenowia* 23: 190 (1993).

New name for *Picris* sp. (Eastern Highlands). Differs from *P. squarrosa* in having bracts which are all straight, the outer ones upright (sometimes slightly squarrose) and not as wide as inner ones. Further diagnostic features are not available currently.

Siloxerus multiflorus Nees in Lehm., *Pl. Preiss.* 2: 244 (1845).

New name for *Rutidosis multiflora*. Field and herbarium studies indicate that *Rutidosis multiflora* is more similar to species of *Siloxerus* than recent authors have thought. This species has been returned to the genus in which it was orginally described.

EPACRIDACEAE

Epacris celata R.K. Crowden, *Muelleria* 8: 319 (1995).

New record for Victoria. Widespread in damp areas on the Snowy Range and Bogong High Plains, extending into New South Wales in the Kosciusko region. This species resembles *E. petrophila* and *E. breviflora*, and has campanulate flowers clustered in heads, but differs in having rounder (length to width ratio c. 1.5), flatter leaves and a somewhat smooth, conspicuous margin that is rarely minutely serrate. There are further differences in leave shape and orientation.

Monotoca billawinica Albr., *Muelleria* 8: 303 (1995).

New name for *Monotoca* sp. (Grampians). Rare and restricted to small areas in the Victoria and Mt Difficult Ranges in the Grampians. Similar to *M. glauca* and *M. scoparia* but characterized by a combination of its robust habit; absence of lignotuber; leaves usually 2.3-4.2 mm wide; long peduncles (0.6-2.7 mm on lowermost spikes), sepals (1.2-1.9 mm), corolla (2.5-3 mm in male flowers) and anthers (1.3-1.8 mm and exserted); glabrous petioles on distal leaves; and red-orange fruits.

Monotoca oreophila Albr., *Muelleria* 8: 299 (1995).

New name for *Monotoca* sp. aff. *elliptica* (Alps). This Victorian endemic is restricted to Snowfields from Mt Baw Baw to Mt Kent, where it grows among rocks of various types. It is characterized by its dense, small leaves (4 -11 mm long, 1.4 -2.8 mm wide) with a pungent apex, its singly borne flowers, the absence of a lignotuber, and more subtle features of the flowers and the overwintering buds. It most closely resembles *M. elliptica*, a coastal species.

Richea victoriana Y. Menadue, *Muelleria* 8: 317 (1995).

New name for *Richea gunnii* in Victoria. First noticed by the author during a chemotaxonomic survey of *Richea*, this endemic Victorian species is known from damp areas on the Baw Baw Plateau and the Blue Range (between Marysville and Taggerty). It resembles *R. gunnii*, now considered to be a Tasmanian endemic, but is a more robust plant with longer, wider leaves that are distinctively twisted.

FABACEAE

Gompholobium inconspicuum Crisp, *Muelleria* 8: 307 (1995).

New name for *Gompholobium* sp. B aff. *uncinatum*. Restricted in Victoria mostly to the upper Genoa River area where growing in open forest and *Allocasuarina nana* heathland. It has tuberculate stems, trifoliolate leaves, and pale lemon-yellow or yellow-green flowers with a minutely ciliate or glabrous keel. Most similar to *G. uncinatum* Cunn. ex Benth. from northern New South Wales and south-east Queensland, but that species has reddish petals and lacks stipules.

***Melilotus officinalis** (L.) Pall., *Reise Russ. Reich.* 3: 537 (1776).

New weed record for Victoria. Collected once from Red Cliffs, this European species differs from *Melilotus albus* in having yellow flowers, longer fruiting racemes (10-25 cm long) and reticulate-rugose (rather than transverse-rugose) pods.

***Ornithopus perpusillus** L., *Sp. Pl.* 743 (1753).

New weed record for Victoria. A European species collected from two localities in South Gippsland, it differs from other species of *Ornithopus* naturalized in Victoria in having stems usually branched at base only, white or pink flowers with calyx teeth c. half as long as tube and corolla 3 - 5 mm long, and straight or slightly curved pods which are constricted between articles.

Podolobium ilicifolium (Andrews) Crisp & P.H. Weston, *Advances in Legume Systematics* 7: 56 (1994).

Podolobium alpestre (F. Muell.) Crisp & P.H. Weston, *Advances in Legume Systematics* 7: 56 (1994).

Podolobium procumbens (F. Muell.) Crisp & P.H. Weston, *Advances in Legume Systematics* 7: 58 (1994).

New names for taxa previously included in *Oxylobium*. The genus *Podolobium* was resurrected in a recent revision. Species of *Podolobium* are distinguished from those of *Oxylobium* by their peltate hairs, trilobed bracts, rigid stipules that are usually recurved or spreading, calyx lobes that are recurved at anthesis, and the warty ridges on the pods.

Pultenaea forsythiana Blakely, *Contr. New South Wales Natl. Herb.* 1: 121 (1941).

Change of rank for *Pultenaea juniperina* var. *mucronata*.

Pultenaea sericea (Benth.) Corrick, *Muelleria* 8: 392 (1995).

Change of rank for *Pultenaea paleacea* var. *sericea*.

Pultenaea williamsonii Maiden, *The Victorian Naturalist* **22**, 99 (1905).

Change of rank for *Pultenaea paleacea* var. *williamsonii*.

In preparation for the *Flora of Victoria*, volume 3, account of *Pultenaea*, M. Corrick (*Muelleria* 8: 391-394) has raised these three varieties to species level, using existing names in two instances.

Pultenaea parrisiae J.D. Briggs & Crisp, *Telopea* 5: 647 (1994) ssp. **parrisiae**.

New name for *Pultenea* sp. aff. *paleacea* (East Gippsland). First collected by Ferdinand von Mueller from upper Upper Genoa River (in 1860) and now known from other sites in East Gippsland as well as New South Wales, this taxon has been hidden within *P. paleacea*. It differs from that species in having flowers pedicellate and only 5-7 mm long (cf. 10-12 mm), and in its more diminutive, procumbent habit (with generally shorter leaves and stipules).

Pultenaea viscosa = **Pultenaea mollis**.

M. Corrick (*Muelleria* 8: 393) has placed *P. viscosa* in synonymy with *P. mollis*.

***Trifolium resupinatum** var. **majus** Boiss., *Fl. Orient* 2: 137 (1872).

***Trifolium resupinatum** var. **resupinatum.**

New weed record for Victoria. Following the account in preparation for *Flora of Australia*, two varieties of *Trifolium resupinatum* are recognized in Victoria. Var. *majus*, native to the Middle East, differs from the Eurasian var. *resupinatum* in having hollow, generally longer and broader stems (to 80 cm long and 5 mm thick), leaflets often 30 mm or more long, dense flowering heads mostly more than 10 mm wide, and flowers with corolla 6-8 mm long. It is currently known only as a roadside weed from Keilor and near Casterton (and may not be truly naturalized).

***Trifolium vesiculosum** var. **vesiculosum** Savi, *Fl. Pis.* 2: 165 (1798).

New weed record for Victoria. Recorded in 1993 as an infestation covering 40 ha on private land and roadside verge in the Little Desert area, possibly as a result of deliberate planting for seed or green manure. This European annual differs from other introduced species of *Trifolium* in having an upright habit, prominently toothed leaflets, inflorescence more than 20 mm long and with all flowers fertile, calyx tube conspicuously inflated (bladdery in fruit), and corolla pale pink to purple, more than 10 mm long and persistent in fruit.

***Vicia monantha** ssp. **triflora** (Ten.) B.L. Burtt & P. Lewis, *Kew Bull.* 1949: 510 (1950).

New weed record for Victoria. This subspecies, also native to Europe, has been found in disturbed areas at several localities in the far north-west of Victoria and at a single site in South Gippsland. It differs from ssp. *monantha* in having racemes 2-5-flowered, corolla 14-20 mm long, pod 3-5 cm long and 10-12 mm wide, and seeds 3.5-5 mm long and blackish. Specimens intermediate between the two subspecies have been reported in Victoria.

***Vicia sativa** ssp. **cordata** (Wulfen ex Hoppe) Asch. & Graebn., *Syn. Mitteleur. Fl.* 6(2): 968 (1909).

New weed record for Victoria. Native to Eurasia and an occasional weed of roadsides and other disturbed areas in Victoria. It differs from ssp. *sativa* in having pods 4-6 mm wide, without regular swellings and dark brown, and seeds 3-5 mm long.

***Vicia villosa** ssp. **eriocarpa** (Hausskn.) P.W. Ball, *Feddes Report.* 79: 45 (1968).

***Vicia villosa** ssp. **villosa**

New weed record for Victoria. Following the account in preparation for *Flora of Australia*, two of four subspecies of the Eurasian species *V. villosa* are recognized in Victoria. Var. *eriocarpa* grows in a few disjunct localities in Victoria, usually on disturbed sites. It differs from var. *villosa* (the other variety in Victoria) in having stems glabrous or appressed pilose, stipules 1-3 mm wide, lower calyx lobes shorter than calyx tube and sparsely ciliate to subglabrous, and pod pubescent.

MYRTACEAE

Callistemon kenmorrisonii Molyneaux, *Muelleria* 8: 379 (1995).

New record for Victoria. Confined to a single population in the upper Betka River catchment of Victoria. It differs from *C. citrinus*, more common in the area, in being a shrub of rock crevices with less regularly hairy rachises, glabrous perigynium (except for irregular patches of hair at base), and generally smaller leaves (c. 15-52 mm long, 3-6 mm wide). Compared with *C. subulatus*, which grows nearby, *C. kenmorrisonii* is a larger bush; has longer, wider and more irregularly arranged leaves; purple rather than crimson anthers; and larger fruits.

OXALIDACEAE

Oxalis thompsoniae B.J. Conn & P.G. Richards, *Austral. Syst. Bot.* 7: 175 (1994).

New name for *Oxalis* sp. *sensu* Joy Thomps. Known from Papua New Guinea, eastern Australia and New Zealand, but its precise distribution in Victoria is unclear (collections currently from Otway Plain, Gippsland Plain and East Gippsland). Like *O. exilis* and *O. rubens* it has hairs directed upwards (antrorse) on the branches, prominent stipules and a slender or absent taproot. It is glaucous (when fresh) like *O. rubens*. but with the apex of the fruit abruptly narrowed as in *O. exilis*. It is further characterized by its fruit being arranged in 3s and always with a dense covering of spreading, septate hairs; seeds very flattened laterally and with indistinct transverse ridges; and stipules with a rounded, elongate apex.

POLYGONACEAE

***Fallopia sacchalinensis** (Schmidt) Ronse Decr., *Bot. J. Linn. Soc.* 98: 369 (1988).

New name for weed species *Reynoutria sacchalinensis*, following a reassessment of generic characters by Ronse-Decraene & Akeroyd (journal citation as above).

PROTEACEAE

Grevillea celata Molyneux, *Muelleria* 8: 311 (1995).

New name for *Grevillea* aff. *chrysophaea* (Nowa Nowa). Endemic to the Bruthen-Nowa Nowa area in East Gippsland, and similar to both *G. alpina* and *G. chrysophaea* which are not known in Victoria east of the Tambo River. It is characterized by resprouting from the roots, the simple to 3-times branched conflorescence with 2-8 flowers, the generally larger pistil (18-25 mm cf. 10-22 mm long in the other two species), and the conspicuous, angled nectary to 2.5 mm high.

RANUNCULACEAE

Ranunculus diminutus B.G. Briggs, *Telopea* 5: 583 (1994).

New name for *Ranunculus* sp. B *sensu* B.G. Briggs & Makinson. A small stoloniferous species of moist habitats on the Volcanic Plains and in East Gippsland. It resembles *R. papulentus* generally but has smaller petals (3.5-6.2 mm long, 0.6-2.0 mm wide), a less robust habit and usually entire leaves (although those of *R. papulentus* can be entire).

VIOLACEAE

Viola sp. A *sensu* T.A. James, *Fl. New South Wales* 1: 438 (1990).

Interim name for *Viola hederacea* ssp. *fuscoviolacea*. This subspecies warrants recognition at species level and will be given a formal name prior to publication of *Flora of Victoria*, volume 3.

URTICACEAE

Parietaria australis (Nees) Blume, *Mus. Bot.* 2: 256 (1857).

New record for Victoria. Mostly restricted to the Grampians and further north, growing in moist, shady habitats in woodland on rocky scarps. Also known from Western Australia and South Australia, this taxon was previously subsumed within *P. debilis*. It differs from that species in having bracts subtending lateral flowers nearly equal in length, broadly triangular-ovate, concealing the flowers entirely except for perianth tips, initially delicate and green but becoming brown and often harder at maturity, and with delicate reticulate venation visible; and nuts which are delicate, and pale brown to pale greenish-brown.

Acknowledgements

The following provided information or read the manuscript: Marco Duretto, Jeff Jeanes, Jim Ross, Neville Walsh.

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In which is incorporated the Microscopical Society of Victoria
Established 1880

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The Field Naturalists Club of Victoria Honorary Membership

Honorary Membership is bestowed on several grounds, one being for those who have been Members of the Club for a continuous period of forty years. Two Members joined the Club in 1955 and will be presented with their Certificates at our December General Meeting.

Mr Eric Allen was elected to membership on 4 April 1955. His involvement has ranged from Honorary Assistant Librarian and Honorary Sales Officer, to Council Member (1961-66) and President (1967-69). Mr Allen has also contributed to this journal and remains a Trustee of the M.A. Ingram Trust.

Dr Gordon Mackenzie was elected to membership on 7 March 1955. His botanical interests, pursued where possible with his medical practice, have centred on endemic plants in the Grampians, including early collection of *Borya* sp.

Both members deserve our congratulations on their long FNCV service.

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Cover: Blue Pincushion *Brunonia australis* is a distinctive feature of the Evans Street Grassland but is uncommon in true basalt plains grassland (see article pages 148-159). *Photograph by Vanessa Craigie.*

Base-line Monitoring of a Significant Grassland Remnant at Evans Street, Sunbury, Victoria

J.W. Morgan[1] and T.S. Rollason[2]

Abstract

The frequency and overlapping cover of native and exotic plant species were determined from 110 x 1m^2 quadrats positioned in a uniform grid over the Evans Street grassland during December 1993. A species list of the cryptogamic flora was also made. Fifty-nine native and 44 exotic species were recorded in quadrats during the survey. Most native species are sparse, occur at low frequency and have low projective foliage cover. Indeed, some species (e.g. *Ptilotus macrocephalus*, *Comesperma polygaloides* and *Stylidium graminifolium* 'plains form') are represented by only one or a few individuals. The frequency of occurrence of exotic species is bimodal with most species occurring in less than 5% of quadrats, but 20% of species also occur in greater than 50% of quadrats. One hundred and one native plant species have now been recorded for the site, making it as rich as the much larger Derrimut Grassland Reserve. Only 49 native species are common to both Evans Street and Derrimut. At least 32 cryptogams were also noted. Evans Street therefore represents one of the few opportunities to conserve species-rich grassland on the basalt plains. Patterns of current weed invasion are documented and some recommendations for assessment of future surveys are provided.

Introduction

Themeda grasslands on the western volcanic or basalt plains have been so thoroughly put to agricultural use since the mid-1800's that much less than 1% now persists (McDougall *et al.* 1992; McDougall and Kirkpatrick 1994). Of this, possibly less than 500 ha is species rich with a minimal weed component (McDougall *et al.* 1992). The basalt plains grassland community is therefore amongst the most threatened in Australia (Frood and Calder 1987; Lunt 1991). Most refugia have survived to this day because they have been protected from intense or prolonged stock grazing and many have been regularly burnt for fire protection (as was the practice along railway lines and roadsides). As such, these small remnants now play a vital role in the conservation of the ecosystem, supporting many species that can no longer be found in other grassland remnants (Stuwe and Parsons 1977).

Only one reserve for the conservation of the basalt plains grassland community has been proclaimed (Derrimut Grassland Reserve) although it has a history of cropping and grazing (Lunt 1990a). Many grassland plants of the region are absent or poorly represented at Derrimut due to this past management regime. Most grassland species (80%) are, as yet, unrepresented in grasslands in permanent conservation reserves (Scarlett *et al.* 1992). All remaining remnants on the Keilor Plains, encompassing some of the best remnants of *Themeda* grassland in western Victoria (and many under imminent threat of urban and industrial development), are therefore vital to the conservation of this flora. The challenge of conserving such a fragmented ecosystem has been addressed by Ross (1993a) who proposed that the best remnants be seen as an integrated unit, linked by common objectives and management. The Evans Street grassland at Sunbury is an important component of this grassland reserve network.

The grassland at Evans Street has received considerable attention from conservationists in the Melbourne region because of its size relative to most other remnants, and its perceived integrity. The biological values of the site have been recognised for some time (Rayner *et al.* 1984; Stuwe 1986; DCE 1990) but it has only recently been temporarily reserved for conservation. The aim of the research reported here was to document the condition of the grassland as it was at the time of reservation (1993) so that future changes could be monitored and an assessment of its condition at the end of the 10 year interim reservation period determined.

Study Site

The Evans Street grassland is approximately 30 km north-west of Melbourne on

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[2] Ramsden Street, Clifton Hill, Victoria 3068

the southern perimeter of the town of Sunbury (37° 35′ S, 144° 44′ E). It is approximately 100 m wide, 3.5 ha in size and is bounded to the east by the residential Evans Street and to the west by the Melbourne-Bendigo railway line. The area can be considered to be urban.

The soil at the site is predominantly a red-brown to grey clay loam on Quaternary basalt. In the centre of the site, a lens of Ordovician silcrete protrudes from the surrounding soil and gives the site its topographical relief. The silcrete area indicates that the basalt soil is (probably) only a thin layer in places and absent altogether in others. As a result, Evans Street is not truly representative of the basalt plains.

The vegetation is primarily free-draining plains grassland dominated by Kangaroo Grass *Themeda triandra* with numerous intertussock species and may be considered similar to the Keilor Plains community described by Sutton (1916) and Willis (1964). The outcropping silcrete area is dominated by *Acacia paradoxa* and contains many species that are uncommon in typical *Themeda* grassland (e.g. *Brunonia australis*, *Stylidium graminifolium* 'plains form').

The site, previously a rail reserve, has been burnt regularly for fire protection for decades (J. Ross *pers. comm.*). The grazing history is unknown but presumably was light or absent altogether. More recently, an ecological burn of the entire site was undertaken approximately nine months prior to this study.

Methods

Data Collection

Eleven 90 m transects were laid out across the site to form a grid to survey the grassland. Permanently marked transects, each approximately 20-30 m apart, ran east to west, i.e. from the roadside fence towards the railway line, stopping approximately 15 m from the rail-line itself. At 10 m intervals along each transect (i.e. 0 m, 10 m, 20 m.....90 m), a 1 m² quadrat was located on the south side of the tape (a total of 110 quadrats were sampled) and all species of vascular plants growing in, or projecting over, the quadrat were identified, recorded and assigned a cover abundance value based on a six point scale, i.e:

+ - projective foliage cover less than 1%
1 - projective foliage cover 2-5%
2 - projective foliage cover 6-25%
3 - projective foliage cover 26-50%
4 - projective foliage cover 51-75%
5 - projective foliage cover 76-100%

One-metre square quadrats were chosen as the sampling unit so that many quadrats could be placed throughout the site to monitor changes in abundance and cover. Small quadrats were chosen ahead of larger quadrats to give more accurate estimates of these changes even though they are probably below the minimal area required for this community (see Lunt 1990b). The sampling grid also allowed for the invasion by exotic species from reserve edge to be quantified.

All sampling was done between 19-29 December 1993. Further observations were made during autumn-winter 1994 and non-vascular plants were collected for identification in July 1994.

Plant Taxonomy

Vascular plant nomenclature throughout this report follows Ross (1993b) and Walsh and Entwisle (1994) whilst non-vascular plant nomenclature follows Catcheside (1980) and Scott (1985).

The survey was conducted late in the growing season of a particularly dry spring. As such, many plants had either completed flowering or had not flowered at all. This presented some difficulty in identification. Difficulties were encountered with the following plants:

**Aira* spp. - this small annual had completed its life cycle at the time of sampling. It is likely to include *Aira cupaniana* and *A. caryophyllea*.

Asperula scoparia - most specimens of *Asperula* observed at the site were *A. scoparia* but some *A. conferta* may have been included.

Plantago spp. - the native Plantago at the site could not be reliably identified because of the lack of fertile material. Both *P. gaudichuadii* and *P. varia* occur at the site and are included in this grouping.

Exotic Asteraceae - identification of some small, infertile specimens to genus was difficult.

Unidentified Liliaceae - some small lilies were not reliably identified but are likely to have been *Arthropodium strictum* and *Caesia calliantha.*

Exotic dicots - some very small, infertile exotic dicots were encountered but not identified to genus level.

Unidentified monocots - some exotic grasses could not be identified to genus because they had completed their life cycle at the time of sampling.

Difficulties in identification to species level were encountered in some instances with the following genera: *Carex, Danthonia, Euchiton, Isolepis, Juncus, Stipa, Trifolium* and *Wahlenbergia.*

Given that the botanical survey was conducted in December, many seasonal species (notably geophytes and annuals) may have been overlooked. Many additional species would undoubtedly be recorded if the area was surveyed during the height of flowering in spring.

Results

A total of 93 species was identified in quadrats during the survey and a further 10 exotic species were recorded but not identified to species level (Appendix 1). Of these, 59 species (57%) were native and 44 species (43%) were exotic. A further 48 species have also been recorded for the site comprising 42 native and 6 exotic species, although it is not certain as to whether all recorded species still persist. The classification of species according to family, life history and growth form is shown in Table 1. Nine percent of native species were annual and 63% of all native species were forbs. The typical basalt plains families (Willis 1964) also predominate at Evans Street, namely Poaceae (33 spp.), Asteraceae (19 spp.), Fabaceae (11 spp.), Liliaceae (7 spp.) and Cyperaceae (6 spp.).

Table 1. Indigenous and exotic species classified according to family, life history and growth form.

Classification	Indigenous	Exotic
Families	36	13
Annuals	9	19
Perennials	92	25
Grasses	28	18
Forbs	65	21
Shrubs	7	4
Trees	1	1
Unclassified	0	6

Most plant species at the site were recorded in few quadrats (Fig. 1). Very few species other than the grassland dominant, *Themeda triandra*, and exotic annual grasses occurred in greater than 50% of quadrats. Given the low percent frequency of most species, it is not surprising that percent foliage cover per quadrat is also very low for most species (Fig. 2). Only *Themeda* has a significant cover (43%) at the site.

Native species richness did not differ greatly on basalt versus silcrete areas (6.71 versus 7.02 species/m²). Some species, however, were restricted to, or more numerous on, the rocky silcrete substrate (e.g. *Arthropodium strictum, Brunonia australis, Stylidium graminifolium* 'plains

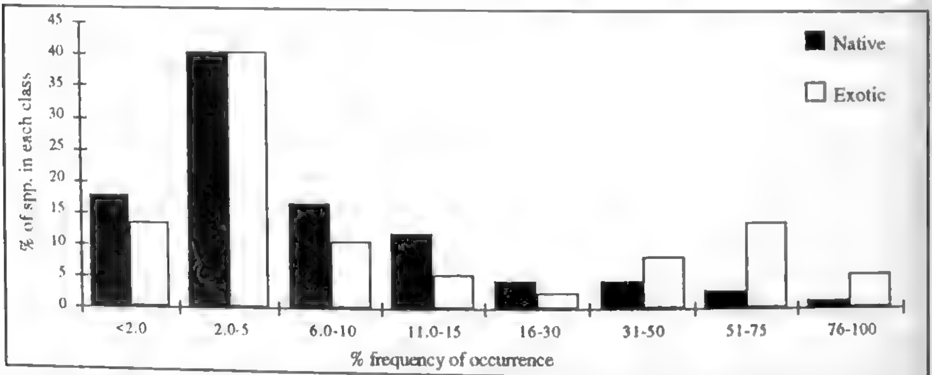

Fig. 1. The frequency of occurrence of native and exotic species (as a % of total number of species in each flora) as determined from 110 x 1 m² quadrats.

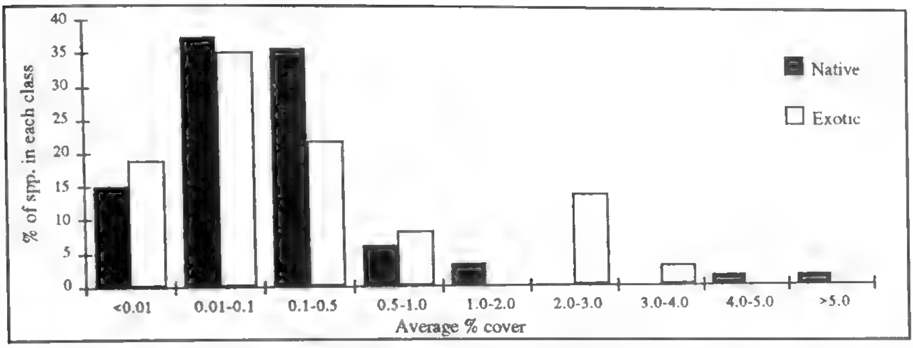

Fig. 2. The mean cover of native and exotic species (expressed as a % of total number of species in each flora) as determined from 110 x 1 m² quadrats.

form', *Acacia paradoxa* and *Dillwynia cinerascens*).

At least 32 non-vascular species were recorded from Evans Street including *Riccia* spp., *Bryum* spp. and *Fissidens* spp. (common components of grasslands) and *Gigaspermum repens*, *Grimmia pulvinata* and *Triquetrella papillata* (species more restricted to the rocky outcropping areas) (Appendix 2).

Of the 151 species recorded at Evans Street, 50 (33%) are exotic species. Whilst numerically significant, most occur infrequently and have low cover. The number of exotic species did, however, outnumber the number of native species in 53% of quadrats.

Highest numbers (Fig. 3) and percent overlapping cover (Fig. 4) of exotic species occur along both edges of the reserve, particularly the more disturbed Evans Street fenceline. Lowest native species richness and percent overlapping cover also occurs here. Exotic species richness throughout the rest of the grassland is similar to that of native species richness. Exotic species cover varies between 10-20% throughout the grassland proper whereas native species overlapping cover varies between 60-80%, most of which is contributed by *Themeda*.

Three groups of exotic species can be recognised at Evans Street (Table 2):

1) Widespread, ubiquitous weeds

These species occur in greater than 50% of quadrats and are found independent of the degree of disturbance.

2) Species that occur throughout the grassland with low (<10%) to moderate (40%) frequency.

These species, such as *Avena fatua*, *Juncus capitatus* and *Plantago lanceolata*, are not restricted to disturbed areas and have not invaded the site to the degree that ubiquitous species have. It is uncertain whether these species will continue to increase their abundance and hence, become ubiquitous at a later date.

3) Disturbance/Edge weeds

These species occur almost exclusively in areas of disturbance. Some, like *Agrostis capillaris* and *Cynodon dactylon*, appear to

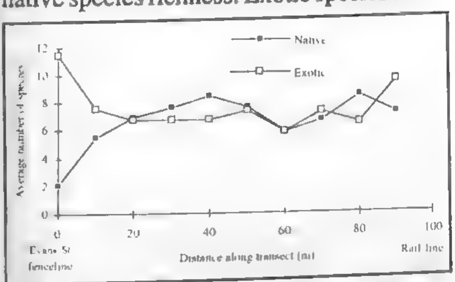

Fig. 3. Average species richness (per m²)of native and exotic species along transects (n=11) running across the Evans Street site.

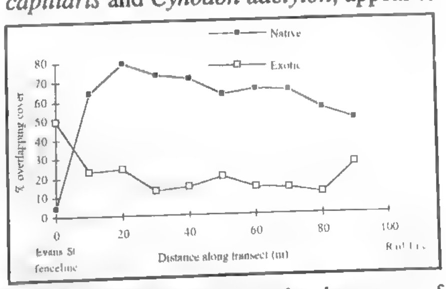

Fig. 4. Average percent overlapping cover of native and exotic species along transects (n=11) running across the Evans Street site.

Table 2. Indigenous and exotic species grouped according to frequency of occurrence and/or degree of site modification.
* Note that exotic species found in disturbed areas are restricted to these areas whereas native species in disturbed areas appear to either tolerate the disturbance or can co-exist with exotic species in such sites.

	Widespread (>50% frequency)	Moderately common (10-40% frequency)	Disturbed Areas*
Exotic Species	*Aira* spp. *Briza minor* *Holcus lanatus* *Hypochoeris radicata* *Romulea rosea* *Trifolium campestre* *Vulpia bromoides*	*Avena fatua* *Centaurium tenuifolium* *Juncus capitatus* *Paspalum dilatatum* *Helminthotheca echioides* *Plantago lanceolata*	*Acacia baileyana* *Agrostis capillaris* *Conyza bonariensis* *Cynodon dactylon* *Lolium perenne* *Phalaris aquatica* *Tragapogon porrifolius* *Vicia* sp.
Native Species	*Plantago* spp. *Schoenus apogon* *Themeda triandra*	*Bossiaea prostrata* *Calocephalus citreus* *Convolvulus erubescens* *Danthonia* spp. *Dichelachme crinita* *Elymus scaber* *Eryngium ovinum* *Gonocarpus tetragynus* *Lomandra filiformis* *Oxalis perennans* *Pimelea curviflora* *Senecio quadridentatus* *Stipa* sp.	*Elymus scaber* *Geranium retrorsum*

be invading from the mown road reserve in Evans Street .

By contrast, when native species are classified into similar frequency or site modification groupings (Table 2), it is apparent that very few native species can co-exist with exotic species in the most disturbed sites. *Elymus scaber*, *Geranium retrorsum* and, to a lesser extent, *Acaena echinata* appear to be exceptions.

Discussion

One hundred and one native plant species have been identified for the Evans Street grassland. This makes it one of the most diverse remnants of grassland on the basalt plains (McDougall *et al.* 1992; McDougall and Kirkpatrick 1994). A further 32 non-vascular plant species were also recorded for the site. Evans Street is likely to be one of the most significant grassland remnants in the Melbourne area in conjunction with the much larger (153 ha) Derrimut Grassland Reserve which supports 102 indigenous species from a variety of plant communities (Lunt 1990a). Indeed, the Evans Street grassland contains many species that are absent or poorly represented at Derrimut (and other grassland remnants in the region), particularly members of the Orchidaceae (e.g. *Diuris lanceolata*, *Thelymitra nuda*, *T. pauciflora*) and Fabaceae (e.g. *Bossiaea prostrata*, *Dillwynia cinerascens*) (Lunt 1990a). It supports one Victorian vulnerable species (*Comesperma polygaloides*), one rare species (*Stipa setacea*) (Gullan *et al.* 1990), at least one undescribed species (*Stylidium graminifolium* 'plains form') and many species that are uncommon (*Brunonia australis*) or are becoming so in grasslands in the Melbourne area (e.g. *Burchardia umbellata, Dianella longifolia, Minuria leptophylla, Pelargonium rodneyanum, Ptilotus macrocephalus, Ptilotus spathulatus, Ranunculus lappaceus*). The Evans Street grassland makes an important contribution to the conservation of the Keilor Plains flora when it is considered that only 49 native species are shared between Derrimut (Lunt 1990a) and Evans Street.

Whilst the site is species rich, many native species occur infrequently and at low cover. There are some species such as *Ptilotus macrocephalus, Ranunculus lappaceus* and *Stylidium graminifolium* 'plains form' that are known from only one or a few individual plants at the site. Such species will need active management to ensure their persistence (i.e. propagation and planting to enhance population size and recruitment). McIntyre *et al.* (1993) has described similar patterns of occurrence for the temperate grasslands of the New England Tablelands area and concluded that much of the grassland flora can be considered to be of 'sparse' occurrence due to its wide geographic range, low levels of dominance and low habitat specificity. At Evans Street, low cover may be due in part to the fact that the site was burnt only nine months prior to sampling. Maximum native species richness at Evans Street (14 species/m²) is also less than that mapped by Patton (1935) for a single quadrat in a similar *Themeda* grassland on the basalt plains. The reasons for this are unknown but may be related to past management of the site.

There was little difference in the total native species richness between basalt and silcrete areas although species composition often varied markedly. *Brunonia australis,* Kennedia prostrata, Stylidium graminifolium 'plains form' and *Acacia paradoxa* were restricted to silcrete areas whilst *Arthropodium strictum* and *Stipa* spp. were much commoner here than on basalt. Similar species substitutions in grasslands as a result of environmental variation, but with no overall change in richness, have also been noted by McIntyre and Lavorel (1994).

Exotic species are numerous at Evans Street and contribute 33% of all species. This is a typical contribution to the grassland flora of the basalt plains (McDougall *et al.* 1992). Their frequency and cover, however, are low in most cases and they (largely) do not detract from the aesthetic quality of the site other than along the perimeter fencelines.

The exotic species at Evans Street differ in two fundamental respects to the type and pattern of occurrence of native species:

i) the frequency of occurrence of exotic species is bimodal (Fig. 1). Like the native species, most exotic species occur very infrequently (<5%), perhaps limited to the edge of the reserve or to disturbed areas. However, unlike native species with an observed unimodal frequency distribution, there is also a second group of species (20% of all exotic species) that occur at high frequency (>50%). This group includes mostly annual grasses (e.g. *Aira* spp., *Briza minor, Vulpia bromoides*) but also includes perennial grasses (*Holcus lanatus*), forbs (*Hypochoeris radicata*) and geophytes (*Romulea rosea*). It is interesting that these species can persist at high frequency in the presence of *Themeda* (and the apparent absence of soil disturbance) whereas most native intertussock species do not.

ii) annual species are far more important in the exotic flora than the native flora (43% of exotic species versus 9% of natives) whilst grasses contribute more to the exotic species (41%) than the native species (29%) (Table 1).

It is suggested that the ubiquitous species will have to be accepted as a part of the flora at Evans Street. They occur too frequently (e.g. *Romulea rosea* occurs in 96% of quadrats and *Briza minor* in 84%) for control to be feasible. Many of these species function without threatening (at their current densities) the integrity of the standing flora. Their impact on seedling recruitment, however, is likely to be greater than their impacts on the standing flora and management should aim to prevent their frequency and cover from further increases. This may be achieved by particular burning regimes (e.g. spring) although these remain largely speculative and untried.

Edge- or disturbance- dependent weeds could be expected to invade the grassland at a slow rate. Most of these species are restricted to the perimeter of the reserve and may be incapable of further encroachment provided that no soil disturbance occurs in the central grassland area. Their presence at the edge of the reserve, however, is correlated with a large reduction in native species diversity and this is likely to continue to decline whilst exotic species remain. Only *Elymus scaber, Geranium retrorsum* and, to a lesser extent, *Acaena echinata* appear to 'tolerate' this disturbance (McIntyre and Lavorel 1994).

The potentially most threatening group of weeds are those species that already occur widely in the grassland (10-40% frequency). It is not known whether these species will continue to increase their frequency and cover. The main threat of this group of weeds is that, unlike the ubiquitous weeds that are typically annual grasses of low biomass, this group of species includes weeds that are capable of directly outcompeting native species because of their potential higher productivity (e.g. *Paspalum dilatatum, Plantago lanceolata*).

Themeda cover averaged 43% per square metre only nine months from burning. At that rate, 100% cover is likely to be reached within 2-3 years. It has been well documented that to maintain species diversity, periodic canopy reduction of *Themeda* is required to prevent smaller plants from being shaded out (McDougall 1989; Lunt 1991). The maintenance of diversity is dependent on the maintenance of the standing flora because many native species do not store seed in the soil for any length of time, i.e. often less than one year (Lunt 1995). As a consequence, if the grassland is left unburnt (e.g. five or more years) and plants die out as a result of old age or shade intolerance, subsequent burning will not return the site to its former diversity but will rather maintain the plants that have survived the inter-fire period (either as seed, dormant buds or standing plants). This phenomenon has been documented elsewhere (Scarlett and Parsons 1990). To maintain the diverse flora of Evans Street, it is crucial that *Themeda* is not allowed to maintain canopy dominance for an extended period of time (e.g. greater than 4 years).

Thirty-two non-vascular species were recorded at Evans Street. By contrast, the Derrimut Grassland Reserve recorded only three moss species (Morgan *et al.* 1993). The difference in species richness may be attributed to differences in the management history of the two sites. Heavy shading under a dense canopy of unburnt *Themeda* is suspected to be the reason for the current paucity of cryptogams at Derrimut whilst many species are also likely to have been adversely affected by the past sheep grazing regime there (Morgan *et al.* 1993; Scarlett 1994). Seven of the species at Evans Street, mostly mosses, appear to be restricted to the higher ground amongst silcrete rock. However, all but six species have also been recorded at Yarra Bend Park, Kew (Sago 1994) suggesting a widespread distribution of many of these species. Many of the cryptogams at Evans Street also appear to be common components of other volcanic grassland soil crusts, particularly on frequently burnt rail and road reserves (e.g. *Riccia* spp., *Lethocolea pansa, Bryum* billardieri, *Fossombronia intestinalis*) (Scarlett 1994; J. Sago *unpublished data*).

Management aims

This base-line study of the condition of the Evans Street grassland in December 1993 has produced some accurate estimates of the frequency of occurrence and the cover of 59 native and 44 exotic species. As such, it allows some specific goals to be stated for this site and a measure of the success of these goals can be determined by future monitoring. We believe that four main aims are appropriate for the Evans Street grassland:

i) the maintenance of current native species richness. This grassland has an important role to play in the conservation of the Keilor Plains flora and every attempt must be made to ensure the persistence of all native species at the site.

ii) populations of rare and vulnerable species, as well as undescribed taxa, should be maintained.

iii) populations of species that are currently very small should be increased. It is known that some species are restricted to one or a few individuals (e.g. *Ptilotus macrocephalus*). These species should be planted in the reserve to increase the viability of their populations. From the plant frequency data obtained in this survey, we are also in a position to make some longer term recommendations. For example, all species that occur in 1% of quadrats should be planted to improve population viability. Species that occur in only 2-5% of quadrats should have seed collected and propagated to buffer against local extinction at some later date. Future surveys would be able to determine which species need to be added or deleted from this list.

iv) exotic species richness and cover should be maintained at, or preferably below, their current levels. All species defined as being restricted to the edge or disturbed areas of the reserve should be controlled.

Interpreting future surveys

Monitoring is an essential way of determining vegetation change over time as it can determine changes in species abundance and cover with some precision. Anecdotal evidence and hearsay cannot be nearly as accurate. To determine whether the grassland is maintaining its high quality, it is imperative that a commitment be made to monitor the site and that future surveys be undertaken in the year following burning (rather than when the grassland has been left unburnt as this may obscure the results). The most important features to consider in the interpretation of results of future surveys are:

a) *Has native species richness been maintained?* The loss of species that at present are represented by only a few individuals should not be viewed as a decline in conservation significance of the site. These species are unlikely to recruit many individuals to the population because of low seed set and, in the absence of vegetative regeneration, will probably disappear once established plants senesce. Plants such as *Ptilotus macrocephalus* and *Comesperma polygaloides* occur in such low numbers that their medium-term persistence at the site relies on an active propagation and re-introduction program. Indeed, manual re-stocking should be viewed as responsible site management.

Species of 'rare' or sparse occurrence (≤3% frequency) will probably remain rare because of their population structures or clumped distributions. At present, 15 native species can be considered to be of 'rare' occurrence. These species include grasses (e.g. *Chloris truncata*), geophytes (e.g. *Burchardia umbellata*), forbs (e.g. *Chrysocephalum apiculatum*) and shrubs (e.g. *Eutaxia microphylla*). The fate of these species will not be immediately obvious to the eye but will have a large impact on whether the site has degraded over the interim protection period. Indeed, it is this group of species that McIntyre *et al.* (1993) suggests are often neglected in conservation strategies because their usual widespread distribution understates their abundance and significance at a regional scale.

Similarly, species such as *Caesia calliantha* and *Eryngium ovinum*, amongst others that are present at moderate frequencies, are sufficiently common at the site to determine how management is affecting the more conspicuous components of the grassland flora. The combined changes in both the common and 'rare' species of the flora should be far better indicators of vegetation condition than the loss of a few already critically low populations of species.

b) *What weeds have changed their abundance and cover over the course of time?* Annual plants are likely to exhibit temporal fluctuations in their abundance and may not be good indicators of directional change. Particularly dry seasons may under-represent the contribution of these species to the flora and this could mistakenly be attributed to management. Far better indicators of vegetation 'health' are likely to be gained by following the changes of those perennial species that already occur commonly throughout the grassland (i.e. 10-40% frequency). Species such as *Paspalum dilatatum* and *Phalaris aquatica*, which appear capable of directly outcompeting co-occurring native species, may continue to increase under the present regime of management and it is this type of change that needs to be determined. Vigilance is al so required to monitor the establishment and spread of weeds that are yet to invade the site. *Stipa neesiana* poses by far the greatest threat of any potential new invader.

c) *Has exotic species richness increased per quadrat?* If so, this will indicate a slow, but steady, invasion of the site by a number of exotic species.

d) *What type of species have declined/increased (e.g. forbs, grasses, shrubs)?* If a growth form is favoured over another, this should indicate something about the management regime employed. Historically, frequent burning and no grazing on rail reserves favoured herbaceous dicotyledons over woody species (Stuwe and Parsons 1977).

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Appendix 1

Summary of Quadrat Data (n=110) and additional species noted at the site either during this work or by DCE (1990). (* denotes exotic species)

Species	Common Name	Av. % Cover/m²	% Frequency
Acacia paradoxa	Hedge Wattle	0.02	5
Acaena echinata	Sheep's Burr	0.13	8
Agrostis aemula	Blown Grass	0.07	5
A. avenacea	Common Blown Grass	0.04	3
**A. capillaris*	Brown-top Bent	0.25	5
**Aira* spp.	Air Grass	0.29	58
* *Anagallis arvense*	Pimpernel	0.005	1
**Anthoxanthum odoratum*	Sweet Vernal Grass	0.16	2
Arthropodium strictum	Chocolate Lily	0.06	4
Asperula conferta/scoparia	Woodruff	0.31	5
*unidentified Asteraceae		0.005	1
**Avena fatua*	Wild Oat	0.15	26
**Briza maxima*	Large Quaking-grass	0.01	3
**B. minor*	Lesser Quaking-grass	0.58	84
Bossiaea prostrata	Creeping Bossiaea	0.89	15
**Bromus diandrus*	Great Brome	0.005	1
**B. hordaceus*	Soft Brome	0.09	9
Burchardia umbellata	Milkmaids	0.01	1
Brunonia australis	Blue Pincushion	0.14	1
Caesia calliantha	Blue Grass-lily	0.13	8
Calocephalus citreus	Lemon Beauty-heads	0.73	21
Carex breviculmis	Short-stem Sedge	0.07	5
Carex spp.		0.06	7
**Centaurium tenuifolium*	Centuary	0.21	42
Cheilanthes austrotenuifolia	Green Rock Fern	0.01	2
Chloris truncata	Windmill Grass	0.19	3
Chrysocephalum apiculatum	Common Everlasting	0.06	3
**Cicendia quadrangularis*	Square Cicendia	0.01	2
Convolvulus erubescens	Pink Bindweed	0.25	15
**Conyza bonariensis*	Tall Fleabane	0.01	1
**Cynodon dactylon*	Couch Grass	0.57	5
**Cyperus tenellus*	Tiny Flat-sedge	0.01	1
Danthonia caespitosa	Common Wallaby Grass	0.12	11
D. duttoniana	Brown-back Wallaby Grass	0.25	5
D. eriantha	Reddish Wallaby Grass	0.07	5
D. penicillata	Slender Wallaby Grass	0.005	1
D. racemosa	Branched Wallaby Grass	0.17	4
D. setacea	Bristly Wallaby Grass	0.04	4
Danthonia spp.		0.34	23
Dianella revoluta	Black-anther Flax-lily	0.05	2
Dichelachne crinita	Long-hair Plume Grass	0.40	35
unidentified dicots		0.01	2
Dillwynia cinerascens	Grey Parrot-pea	0.01	2
Drosera peltata ssp. *peltata*	Pale Sundew	0.03	5
Elymus scaber	Common Wheat Grass	0.49	38
Eryngium ovinum	Blue Devil	1.33	42
**Euchiton* sp.		0.005	1
Eutaxia microphylla	Common Eutaxia	0.14	1
Geranium retrorsum	Grassland Crane's Bill	0.07	9
Gonocarpus tetragynus	Common Raspwort	0.12	15
Haloragis heterophylla	Varied Raspwort	0.07	9
**Helminthotheca echiodes*	Ox-tongue	0.52	34

Appendix 1 (cont.)

Summary of Quadrat Data (n=110) and additional species noted at the site either during this work or by DCE (1990). (* denotes exotic species)

Species	Common Name	Av. % Cover/m²	% Frequency
**Holcus lanatus*	Yorkshire Fog	2.71	73
Hypericum gramineum	Small St John's Wort	0.02	4
**Hypochoeris radicata*	Cat's Ears	2.84	52
Isolepis spp.		0.02	4
Juncus bufonius	Toad Rush	0.05	9
**J. capitatus*	Dwarf Rush	0.06	13
Juncus spp.		0.11	9
**Leontodon taraxacoides*	Hairy Hawkbit	0.07	5
Leptorynchos squamatus	Scaly Buttons	0.04	4
unidentified Liliaceae		0.03	1
**Lolium perenne*	Perennial Rye-grass	0.04	4
Lomandra filiformis	Wattle Mat-rush	0.43	20
L. nana	Dwarf Mat-rush	0.05	5
**Nassella trichotoma*	Serrated Tussock	0.03	2
Oxalis perennans	Grassland Wood Sorrel	0.13	26
Oxalis sp.		0.04	7
**Paspalum dilatatum*	Paspalum	2.63	14
Pentapogon quadrifidus	Five-awned Spear Grass	0.10	7
**Peterahagia velutina*	Hairy Pink	0.01	2
**Phalaris aquatica*	Canary-grass	0.17	3
Pimelea curviflora	Curved Rice-flower	0.27	14
P. humilis	Common Rice-flower	0.005	1
**Platago coronopus*	Buck's-horn Plantain	0.005	1
**P. lanceolata*	Ribwort	2.72	41
P. gaudichaudii/varia	Native Plantain	4.31	57
Poa sieberiana	Grey Tussock Grass	0.49	5
unidentified Poaceae sp. 1		0.04	4
unidentified Poaceae sp. 2		0.10	6
**Romulea rosea*	Onion-grass	2.20	96
**Rumex acetosella*	Sheep Sorrel	0.04	3
Schoenus apogon	Common Bog Sedge	1.06	51
Senecio quadridentatus	Cotton Firewood	0.08	11
Solenogyne dominii	Solenogyne	0.04	4
**Sonchus oleraceus*	Sow Thistle	0.05	9
Stipa blackii	Crested Spear Grass	0.35	13
S. setacea	Corkscrew Spear Grass	0.03	1
Stipa spp.		0.06	3
Stylidium graminifolium 'plains form'	Grass Trigger-plant	0.14	1
**Trifolium arvense*	Hare's-foot Clover	0.07	5
**T. angustifolium*	Narrow-leaf Clover	0.04	3
**T. campestre*	Hop Clover	3.01	57
**T. subterraneum*	Subterranean Clover	0.04	3
**Trifolium* spp.		0.01	3
Themeda triandra	Kangaroo Grass	43.39	91
unidentified thistle		0.03	2
**Tragopogon porrifolius*	Salsify	0.005	1
Tricoryne elatior	Yellow Rush-lily	0.28	7
Veronica gracilis	Slender Speedwell	0.14	1
**Vicia* sp.	Vetch	0.06	6
**Vulpia bromoides*	Squirrel-tail Fescue	0.72	70
Wahlenbergia sp.	Bluebell	0.005	1

Appendix 1 (cont.)

1993 = those plants observed during the 1993 survey.

Other species not recorded in quadrats during survey		1993	Other species not recorded in quadrats during survey		1993
**Acacia baileyana*	Cootamundra Wattle	#	*Microtis unifolia*	Common Onion Orchid	
Acacia melanoxylon	Blackwood	#	*Minuria leptophylla*	Minnie Daisy	#
Calotis scapigera	Tufted Burr Daisy		*Oxalis radicosa*	Oxalis	
Centipeda minima	Centipeda		*Pelargonium rodneyanum*	Magenta Stork's Bill	#
Centrolepis aristata	Centrolepis		*Pimelea glauca*	Smooth Rice-flower	#
Comesperma polygaloides	Small Milkwort	#	**Pinus* sp.		
Crassula sieberiana	Sieber Crassula	#	*Poa labillardieri*	Common Tussock Grass	# #
**Cyperus rotundus*	Nut Grass	#	*Podolepis jaceoides*	Showy Podolepis	#
Danthonia auriculata	Lobed Wallaby Grass		*Ptilotus macrocephalus*	Feather Heads	#
Daucus glochidiatus	Austral Carrot		*Ptilotus spathulatus*	Pussy Tails	#
Dianella longifolia	Pale Flax-lily	#	*Ranunculus lappaceus*	Australian Buttercup	#
Dichondra repens	Kidney Weed	#	**Rosa rubiginosa*	Sweet Briar	#
Diuris lanceolata	Golden Moths		**Rubus fruticosus* ssp. agg.	Blackberry	#
Drosera glanduligera	Scarlett Sundew		*Rumex dumosus*	Wiry Dock	#
Drosera whittakari	Scented Sundew	#	*Sclerolaena muricata*	Five-spined Bassia	#
Epilobium biardierianum	Robust Willow-herb		*Stackhousia monogyna*	Creamy Candles	#
E. hirtigerum	Hairy Willow-herb		*Thelymitra nuda*	Plain Sun-orchid	
Glycine tabiacina	Variable Glycine	#	*Thelymitra pauciflora* spp. agg.	Sun-orchid	#
Goodenia pinnatifida	Cut-leaf Goodenia	#	*Thysanotus patersonii*	Twining Fringe-lily	
Halorgis aspera	Rough Raspwort		*Vittadinia* sp.	New Holland Daisy	#
Isolepis marginata	Little Club Sedge		*Wahlenbergia communis*	Tufted Bluebell	#
Juncus radula	Hoary Rush		*W. gracilenta*	Annual Bluebell	
Juncus usitatus	Rush		*W. stricta*	Tall Bluebell	
Kennedia prostrata	Running Postman	#			
**Lycium ferocissimum*	Boxthorn	#			
Lythrum hyssopifolia	Small Loosestrife				

Appendix 2

Non-vascular species recorded at Evans Street.
* restricted to high ground, amongst silcrete rock.

MOSSES

Bartramiaceae
Bartramia papillata
B. stricta

Bryaceae
Bryum argenteum
B. billardieri
B. dichotomum
Bryum sp.

Dicranaceae
Campylopus clavatus
**C. introflexus*

Ditrichaceae
Ceratodon purpureus

Fissidentaceae
Fissidens bifrons
F. taylorii
F. vittatus

Funariaceae
Funaria hygroametrica

Gigaspermaceae
**Gigaspermum repens*

Grimmiaceae
**Grimmia pulvinata*

Hypnaceae
**Hypnum cupressiforme*

Polytrichaceae
**Polytrichum juniperinum*

Pottiaceae
Acaulon integrifolium
Barbula crinita
Barbula sp.
Didymodon luehmanni
**Triquetrella papillata*

LIVERWORTS

Acrobolbaceae
Lethocolea pansa

Aytoniaceae
Asterella tenera

Cephaloziellaceae
Cephaloziella exiliflora

Codoniaceae
Fossombronia intestinalis
Fossombronia sp.

Geocalycaceae
**Lophocolea semiteres*

Ricciaceae
Riccia bifurca
R. cartilaginosa
R. crozalsii

LICHENS

Cladoniaceae
Cladonia sp.
undifferentiated crustose species

Reptiles and Amphibians of the Melbourne Area

S.A. Larwill[1]

Abstract

An inventory of reptiles and amphibians of the Melbourne area was compiled using records registered on the Atlas of Victorian Wildlife database (Wildlife Section, Department of Conservation and Natural Resources). The Melbourne area was defined by municipal boundaries and was divided into four physiographic regions used to characterise the distribution of species. An annotated species list was compiled including: a review of common names and scientific names of all species with notes on recent revisions to taxonomic nomenclature; notes on the distribution of each species; a review of the status of each species within the Melbourne area; a review of the conservation status of species at the state and national levels and notes on identification of some cryptic species.

Introduction

The objective of this paper is to provide an inventory of reptiles and frogs for use by naturalists in the Melbourne area. It includes a full list of species recorded for the region, notes on distribution and abundance, a review of changes in scientific names and some notes on identification. It is not intended that it be used as a key for identification. A number of good references are available for this purpose (e.g. Cogger 1992; Hero *et al.* 1991; Coventry and Robertson 1991; Weigel 1990; Wilson and Knowles 1992; Barker and Grigg 1977; Littlejohn 1987).

Since Littlejohn (1963), Martin (1965) and Rawlinson (1965) published early inventories of amphibians and reptiles of the Melbourne area, new species have been regularly recorded from the region (e.g. Martin *et al.* 1966; Littlejohn and Harrison 1987). Despite the time that has elapsed since their publication, these early papers still provide useful references for identification of the more common species. However, as inventories of species abundance and distribution and as guides to species taxonomy, they are now largely out of date and remain of historical value only. In addition, these early papers did not include an inventory of lizard species from the region and a widely available list has not since been published.

A number of recent studies published by government departments or other research organisations on behalf of government authorities provide updated species inventories and assessments of distribution and abundance of reptiles and amphibians in the Melbourne area (e.g. Schulz *et al.* 1991a; Meredith *et al.* 1991; Wallis *et al.* 1990; Yugovic *et al.* 1990). Although comprehensive, these studies have limited public availability. Similarly, a number of comprehensive reviews of the fauna of the Melbourne region have been published by the Land Conservation Council (e.g. LCC 1991; Lumsden *et al.* 1991; LCC 1985). However, these studies incorporate a large area including major parts of the eastern and western highlands, extending north to Seymour and including much of the western basalt plains, Bellarine Peninsula, Westernport region and South Gippsland. This extensive coverage limits their applicability to the fragmented habitat remnants of suburban Melbourne, most of which are excluded from the LCC studies. An overview of the reptiles and amphibians for use by naturalists in the Melbourne area is therefore warranted.

It is widely recognised that an accurate taxonomic nomenclature is critical to effective conservation of species biodiversity (e.g. Donnellan *et al.* 1993; Parnaby 1991). There is considerable electrophoretic and morphometric analysis of species groups yet to be undertaken by taxonomists and on-going changes in nomenclature can be expected. A number of widely used references on reptiles and amphibians use zoological nomenclature that was out of date even at the time of publication (e.g. Jenkins and Bartell 1980; Wilson and Knowles 1992). This causes confusion over species identification, and may have implications

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for conservation of species when outdated zoological nomenclature is used in the context of conservation planning and land-use planning. Scientists and naturalists should aim to use the most accurate zoological nomenclature available at the time of publication.

Confusion caused by changes in scientific names is compounded by the absence of a published list of common names for Australian frogs and reptiles. Individual species are referred to by a variety of names in the literature. For example *Limnodynastes dumerilii* is variously referred to as the Bullfrog (e.g. Littlejohn 1963), the Southern Bullfrog (e.g. Lumsden *et al.* 1991), the Pobblebonk Frog (e.g. Hero *et al.* 1991) and the Eastern Banjo Frog (e.g. Cogger 1992). The common names and zoological names of species occurring in the Melbourne area are reviewed in this paper.

Study Area

For the purposes of the present study, the Melbourne area is defined by municipal boundaries incorporating the Metropolitan Municipalities (MMBW 1987) and five outer municipalities to the north and west (Fig. 1), Werribee, Melton, Bulla, Whittlesea and Eltham (Department of Crown Lands and Survey 1981). This area is smaller than the Greater Melbourne Area referred to in a number of government reports (e.g. Schulz and Webster 1991b) but corresponds approximately to the area chosen by Littlejohn (1963), Martin (1965) and Rawlinson (1965). The names and boundaries of these municipalities have been reviewed since the data were collated for the present study. The study area corresponds approximately to the new municipal boundaries of the Metropolitan Municipalities and the five outer municipalities of Wyndham, Melton, Hume, Whittlesea and Nillumbik (Department of Finance 1995).

The study area contains a number of representative physiographic regions (Fig. 2): the west Gippsland Plains to the south-east; the foothills of the eastern uplands to the north-east; the foothills of the western uplands to the north-west and the volcanic plains to the north and west (Emison *et al.* 1987). Each region has an associated set of characteristic habitats and many of the reptile and amphibian species are associated with one or other of these physiographic regions.

The major habitat types of the volcanic plains are the grassy ecosystems on the newer volcanic soils characterised by grasslands and open woodlands. Other habitat zones include coastal, riparian and wetland features. Much of the area is now modified as a result of residential, industrial and agricultural development. Few large

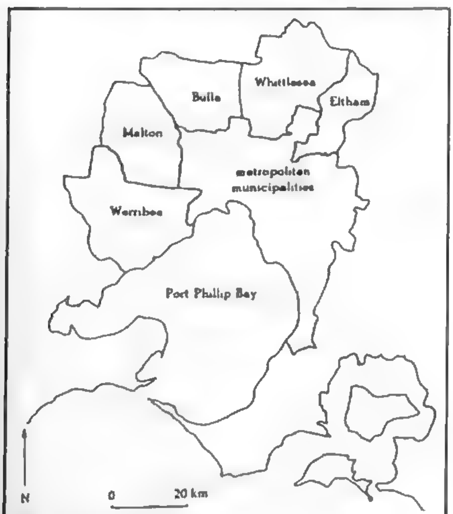

Fig. 1. Study area.

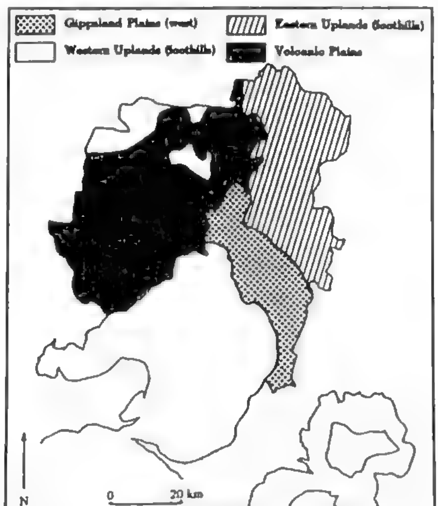

Fig. 2. Physiographic regions of the study area.

intact habitat zones remain, with the exception of larger broad-acre farming areas with relatively low intensity farm practices.

The habitat associations of the foothills of the western uplands are characterised by low hillslopes of woodland and open-forest types. These areas have been intensively developed for agricultural purposes and few large refuges remain.

The foothills of the eastern uplands feature low hillslopes supporting dry woodland habitats, montane and damp sclerophyll forest remnants and floodplain riparian features. Larger remnants are found in a number of regional parks under conservation management including Yarra Valley Park, Warrandyte State Park and Plenty Gorge Park.

The west Gippsland plains are characterised by floodplain, coastal scrub and heath associations. Wetlands, such as the vestiges of Carrum Swamp, are an important habitat feature and constitute the most significant habitat remnants in this region which has been intensively developed for residential and industrial uses.

Inventory of Species

A collated list of reptile and amphibian records for the study area was provided by the Atlas of Victorian Wildlife (Wildlife Section, Department of Conservation and Natural Resources) in April 1994. With one exception, all reptile and amphibian taxa recorded for the study area on the Atlas database are included in the inventory below, including species which have been introduced to the Melbourne area as a result of release or escape from captivity. The Yellow-bellied Sea Snake *Pelamis platurus*, which occurs in marine habitat on Australia's northern coastline, is represented in the database by a single record from the Melbourne area and is not included in the inventory.

Zoological names follow Cogger (1992), incorporating the taxonomic revisions of Hutchinson *et al.* (1990), Hutchinson and Donnellan (1992), and Rawlinson (1991). Notes on zoological nomenclature are provided for species which have undergone recent taxonomic revision and for which some confusion may arise due to the on-going use of old names in the literature.

Where available, common names are taken from the Atlas of Victorian Wildlife. The total number of records for the study area registered on the Atlas of Victorian Wildlife database prior to April 1994 is presented for each species. The database includes records of all specimens held at the National Museum of Victoria plus records submitted to the Atlas database by field scientists and naturalists. Submitting all fauna records to the database is a condition of all Wildlife Research Permits issued in Victoria by the Wildlife Management Section, Flora and Fauna Branch, Department of Conservation and Natural Resources. It should be noted that such a permit is required for any capture or handling and releasing of native wildlife in Victoria. Notes on the distribution, status and identification of species are based on my own knowledge of the reptiles and frogs of the Melbourne area combined with background information from Yugovic *et al.* (1990), Meredith *et al.* (1991), Lumsden *et al.* (1991), Coventry and Robertson (1991), Brook (1975) and Hero *et al.* (1991). Notes on the status of each species in the Melbourne area include, where relevant, reference to the following listings of threatened taxa within Victoria and Australia: the *List of Threatened Fauna in Victoria* (Baker-Gabb 1993), Schedule 2 of the (Victorian) Flora and Fauna Guarantee Act (1988), Schedule 1 of the (Commonwealth) Endangered Species Protection Act (1992) and *The Action Plan for Australian Reptiles* (Cogger *et al.* 1993). Status in the Melbourne region does not in all cases correlate with the total number of records on the Atlas of Victorian Wildlife. Cryptic or rarely encountered species may be poorly represented on the database despite being relatively common. Other species, such as *Varanus varius*, may be represented by a high total number of records consisting predominantly of historical records and yet may have been recorded only rarely in recent years.

CLASS AMPHIBIA

FAMILY MYOBATRACHIDAE

Crinia parinsignifera
Common Name: Plains Froglet
Nomenclature: Previously referred to as *Ranidella parinsignifera* (Cogger *et al.* 1983); revised by Heyer *et al.* (1982).
Atlas Records: 65
Status: Locally common.
Distribution: Restricted. Victorian distribution mainly north of the Divide with the southern limit extending into the study area in the uplands and foothills to the north.
Notes: Morphologically similar to *Crinia signifera*. The advertisement call of *C. parinsignifera* is superficially similar to the territorial call of *C. signifera* which can be heard sporadically during the day, at the onset of calling activity at dusk, or at breeding sites where calling males are present in high numbers. As for all amphibian species, identification by advertisement call should be confirmed by hand-capture when possible.

Crinia signifera
Common Name: Common Froglet
Nomenclature: Previously referred to as *Ranidella signifera* (Cogger *et al.* 1983); revised by Heyer *et al.* (1982).
Atlas Records: 1108
Status: Abundant.
Distribution: Occurs throughout the study area.
Notes: Morphologically similar to *Crinia parinsignifera.*

Geocrinia victoriana
Common Name: Victorian Smooth Froglet
Atlas Records: 135
Status: Locally common.
Distribution: Restricted, confined to damp forest habitats of the eastern uplands and south Gippsland plains.

Limnodynastes dumerilii
Common Name: Southern Bullfrog
Nomenclature: There are three Victorian subspecies: *Limnodynastes dumerilii dumerilii*, *L. dumerilii insularis*, and *L. dumerilii variegata* (Martin 1972). *Limnodynastes dumerilii dumerilii* occurs in the northwest of the study area and *L. dumerilii insularis* occurs in the eastern half of the study area with intergrades between the two subspecies occurring in the areas of overlap. *Limnodynastes dumerilii variegata* does not occur in the Melbourne area.
Atlas Records: 443
Status: Common in the Melbourne area.
Distribution: Widespread, occurs in wetland habitats throu ghout the study area.
Notes: Also known as the Eastern Banjo Frog and the Pobblebonk Frog. The most common burrowing frog in the Melbourne area, sometimes found in suburban garden beds particularly in the outer eastern suburbs.

Limnodynastes peronii
Common Name: Striped Marsh Frog
Atlas Records: 139
Status: Uncommon in the Melbourne area.
Distribution: Widespread, occurs in permanent water bodies throughout the study area, with records from the volcanic plains being rare.

Limnodynastes tasmaniensis
Common Name: Spotted Marsh Frog
Atlas Records: 900
Status: Abundant.
Distribution: Occurs throughout the study area.
Notes: There are two call races of this species: a northern call race generally occurring north of the Divide and a southern call race generally occurring south of the Divide (Hero *et al.* 1991; Littlejohn 1963).

Neobatrachus sudelli
Common Name: Common Spadefoot Toad
Atlas Records: 150
Status: Uncommon in the Melbourne area.
Distribution: Restricted, confined primarily to the basalt plains in the west although the species has been recorded throughout the low hill slopes and plains.
Notes: Males of the species have explosive breeding periods characterised by short (2-3 days) intense periods of calling after heavy rains. It is therefore less often encountered than other species with more prolonged breeding periods.

Pseudophryne bibronii
Common Name:Bibron's Toadlet
Atlas Records: 215
Status: Common in the Melbourne area.
Distribution: Restricted, generally occurs throughout higher altitudes of the forested habitats of the uplands to the east and north-east and the drier grassy woodlands to the north-west. Uncommon on the volcanic plains.

Pseudophryne semimarmorata
Common Name: Southern Toadlet
Atlas Records: 225

Status: Common in the Melbourne area.
Distribution: Restricted, occurs in the forested habitats of the foothill forests as well as heathland and coastal habitats. Within the study area restricted to the foothills to the east and the Gippsland plains in the south.

FAMILY HYLIDAE

Litoria ewingii
Common Name: Southern Brown Tree Frog
Atlas Records: 720
Status: Common in the Melbourne area.
Distribution: Widespread, throughout the study area, but occurrence in the western volcanic plains is restricted to wetland and riparian habitats.
Notes: Similar to both *Litoria paraewingii* and *L. verreauxii verreauxii*. Most commonly encountered of the tree frogs (genus *Litoria*) in the Melbourne area. It is represented in Victoria by a northern form and a southern form. Only the southern form occurs in the Melbourne area (Atlas of Victorian Wildlife). Also known as Ewing's Tree Frog.

Litoria lesueuri
Common Name: Lesueur's Frog
Atlas Records: 22
Status: Rare in the Melbourne area.
Distribution: Restricted, occurs in the volcanic plains in the north-west where it is recorded from riparian habitats on Jackson Creek and Deep Creek. Also recorded in the foothills of the central highlands in the north-west. In Victoria, generally confined to montane streams of the uplands in forested habitat.
Notes: Also known as the Rocky River Tree Frog and Lesueur's Tree Frog.

Litoria paraewingii
Common Name: Plains Brown Tree Frog
Atlas Records: 7
Status: Rare in the Melbourne area.
Distribution: Restricted. Victorian distribution predominantly north of the Divide with the southern limit of the species range abutting the north of the study area. Four of the seven records from the study area are from a single location in the upper Plenty Valley.
Notes: Similar to both *Litoria ewingii* and *L. verreauxii verreauxii*. Records of the species from Gardners Creek in Melbourne are likely to be either misidentifications or introductions due to escape or release from captivity.

Litoria peronii
Common Name: Peron's Tree Frog
Atlas Records: 22
Status: Rare in the Melbourne area.
Distribution: Occurs in wetland and riparian habitats of the drier open forests of the foothills to the north-east and north and also recorded from damp sclerophyll forest habitats. Most records from the study area are located in the upper Plenty and middle Yarra Valleys.

Litoria raniformis
Common Name: Growling Grass Frog
Atlas Records: 272
Status: Uncommon in the Melbourne area.
Distribution: Occurs in deep permanent water bodies throughout the region.
Notes: There is some evidence that this species is declining throughout its range (e.g. Tyler 1994; Sadlier 1994) in south-eastern Australia. Similarly, anecdotal reports suggest that the species has declined in abundance in the Melbourne area where it was once described as common in grassy margins of small streams (Littlejohn 1963). The significance of the decline in the region is the subject of recent debate and warrants further investigation (Appleby 1994; Larwill and Kutt 1994). Indeed, further investigation is needed to determine the severity of the decline observed throughout south-east Australia. Sometimes referred to as the Southern Bell Frog.

Litoria verreauxii
Common Name: Verreaux's Tree Frog
Atlas Records: 332
Status: Locally common.
Distribution: Occurs throughout the study area except coastal areas to the south-west. Uncommon from habitats in the western volcanic plains.
Notes: Similar to both *Litoria ewingii* and *L. paraewingii*. Two subspecies occur in Victoria: *L. verreauxii verreauxii* and *L. verreauxii alpina*. *Litoria verreauxii alpina* is confined to higher altitudes and does not occur in the study area. Therefore all records of *Litoria verreauxii* from within the Melbourne region are taken to be *Litoria verreauxii verreauxii*. Also known as the Whistling Tree Frog.

CLASS REPTILIA

FAMILY CHELIDAE

Chelodina expansa
Common Name: Broad-shelled Tortoise
Atlas Records: 3
Status: Introduced to the Melbourne area. Listed as 'Insufficiently Known'

(suspected Rare, Vulnerable or Endangered) in Victoria, (Baker Gabb 1993).
Distribution: Victorian distribution confined to the Murray Valley in the north-west of the state. Introduced to the Melbourne area where it has been recorded from billabongs in the middle Yarra region. Also known as the Broad-shelled River Turtle.

Chelodina longicollis
Common Name: Common Long-necked Tortoise
Atlas Records: 63
Status: Uncommon in the Melbourne area.
Distribution: Widespread, occurs throughout the study area in the rivers, major streams and wetlands. Often seen basking on rocks or logs at the water's edge.
Notes: The only indigenous and most commonly encountered freshwater tortoise in the Melbourne area. Also known as the Eastern Snake-necked Turtle.

Emydura macquarii
Common Name: Murray River Tortoise
Atlas Records: 2
Status: Introduced to the Melbourne area, uncommon.
Distribution: Victorian distribution confined to the Murray River valley in the north-west of the state. Introduced and uncommon in the Melbourne area, recorded from the middle Yarra Valley and the upper Merri Creek. Also known as the Murray Turtle and, previously, as the Macquarie Tortoise.

FAMILY GEKKONIDAE

Phyllodactylus marmoratus
Common Name: Marbled Gecko
Atlas Records: 60
Status: Rare in the Melbourne area.
Distribution: Restricted, occurs in the dry forests of the foothills but most commonly encountered in riparian habitats of the western and northern basalt plains, where it can be found in rocky outcrops or beneath basalt boulders. Often found beneath exfoliating bark of River Red Gums *Eucalyptus camaldulensis*.
Notes: The only member of the gecko family recorded in the Melbourne area.

FAMILY PYGOPODIDAE

Delma impar
Common Name: Striped Legless Lizard
Atlas Records: 79
Status: Rare in the Melbourne region. Nationally threatened species. Listed on Schedule 1 of the (Commonwealth) Endangered Species Protection Act (1992). Listed as 'Vulnerable' in Australia (Cogger *et al.* 1993). Listed on Schedule 2 of the (Victorian) Flora and Fauna Guarantee Act (1988). Listed as 'Vulnerable in Victoria', (Baker-Gabb 1993).
Distribution: Restricted distribution in the Melbourne area. Occurs almost exclusively in the grassy habitats of the western basalt plains (grassy woodlands and treeless grasslands). Most commonly recorded in native grassland habitat but also found in exotic vegetation.
Notes: The west of the Melbourne area is one of the strongholds of the species range, with other recent records occurring from the Canberra region, west of Heathcote in central Victoria and the volcanic plains of the Colac/Ballarat regions. *Delma impar* is a cryptic species rarely encountered. Many of the known records originate from specimens located during physical destruction of their grassland habitat including cultivation, excavation, grading, burning and removal of surface boulders.

Delma inornata
Common Name: Olive Legless Lizard
Atlas Records: 1
Status: Rare in the Melbourne area.
Distribution: Restricted, single record from grassy woodland habitat in Gellibrand Hill Park. This record is in need of confirmation.

Pygopus lepidopodus
Common Name: Common Scaly-foot
Atlas Records: 1
Status: Extremely rare in the Melbourne area, probably locally extinct.
Distribution: Restricted, represented by a single museum specimen collected from the Frankston area pre-1900. Victorian distribution concentrated in drier habitats of the north-west of the state with occasional records from the Mornington Peninsula and East Gippsland.

FAMILY AGAMIDAE

Amphibolurus muricatus
Common Name: Tree Dragon
Atlas Records: 121
Status: Locally common in some areas.
Distribution: Widespread throughout much of the study area, but rare in the western basalt plains where it is confined to riparian woodland remnants.

Notes: Also known as the Jacky Lizard. Most often encountered agamid (dragon) lizard in the Melbourne area.

Physignathus lesueurii howittii
Common Name: Gippsland Water Dragon
Atlas Records: 1
Status: Introduced to the Melbourne area.
Distribution: Victorian distribution confined to East Gippsland east of the Thomson River. Any records from the study area represent introduced individuals escaped or released from captivity.

Pogona barbata
Common Name: Eastern Bearded Dragon
Atlas Records: 5
Status: Rare in the Melbourne area.
Distribution: Restricted, occurring in suitable drier habitat isolates in the foothill forest in the north of the study area. Within Victoria generally occurs in drier forests and woodland habitats north of the Divide.

Tympanocryptis diemensis
Common Name: Mountain Dragon
Nomenclature: Previously referred to as *Amphibolurus diemensis* (Cogger *et al.* 1983); *Tympanocryptis* adopted by Witten (1984) following Storr (1982).
Atlas Records: 17
Status: Rare in the Melbourne area. Listed as 'Insufficiently Known' (suspected Rare, Vulnerable or Endangered) in Victoria (Baker-Gabb 1993).
Distribution: Restricted, confined to the dry upland forests to the north-east and north-west of the study area.
Notes: Adult *Tympanocryptis diemensis* are considerably smaller than adult *Amphibolurus muricatus*.

Tympanocryptis lineata pinguicolla
Common Name: Southern Lined Earless Dragon
Atlas Records: 15
Status: Nationally threatened species. Listed as 'Vulnerable' in Australia (Cogger *et al.* 1993). Listed as 'Endangered in Victoria' (Baker-Gabb 1993). Listed on Schedule 2 of the (Victorian) Flora and Fauna Guarantee Act (1988). Regionally rare and possibly vulnerable to extinction.
Distribution: Restricted, recent Victorian records are from only three locations, all from within the Melbourne area since 1987. All three locations support rocky escarpment grasslands on the western basalt plains.
Notes: Further investigation of the species distribution and status is urgently required.

FAMILY VARANIDAE

Varanus varius
Common Name: Tree Goanna
Atlas Records: 222
Status: Rare and restricted possibly locally extinct. Listed as 'Insufficiently Known' (suspected Rare, Vulnerable or Endangered) in Victoria (Baker-Gabb 1993).
Distribution: Now restricted to damp sclerophyll and dry open forest habitats to the north and north-east.
Notes: This species was probably once common and widespread in the woodlands and open-forests of the Melbourne area (e.g. Ward 1966). Of the 222 records registered on the Atlas of Victorian Wildlife only 17 records have been registered since 1983. Also known as the Lace Monitor.

FAMILY SCINCIDAE

Bassiana duperryi
Common Name: Eastern Three-lined Skink
Nomenclature: Previously included in *Leiolopisma trilineata* (Cogger *et al.* 1983); renamed *Leiolopisma duperryi* by Greer (1982); included in the genus *Pseudemoia* by Cogger (1992); revised by Hutchinson *et al.* (1990).
Atlas Records: 52
Status: Uncommon in the Melbourne area.
Distribution: Occurs throughout the study area in stony habitats of the volcanic plains and drier foothill forests.

Ctenotus robustus
Common Name: Large Striped Skink
Atlas Records: 123
Status: Locally common.
Distribution: Restricted to the dry grassy ecosystems of the newer volcanic plains occurring in rocky habitats on stony rises and escarpments.

Egernia coventryi
Common Name: Swamp Skink
Atlas Records: 1
Status: Rare in the Melbourne area. Listed as 'Rare' in Victoria (Baker-Gabb 1993).
Distribution: Restricted, confined to the South Gippsland plains where it occurs in Swamp Paperbark and other wetland/swamp woodland habitats in the Mornington Peninsula and Western Port

region. Only recorded from the south-east of the study area.

Egernia cunninghami
Common Name: Cunningham's Skink
Atlas Records: 96
Status: Uncommon in the Melbourne area.
Distribution: Restricted to the newer volcanic soils. Occurring in stony rises and rocky outcrops of escarpment grassland and woodland throughout the western basalt plains.

Egernia saxatilis intermedia
Common Name: Black Rock Skink
Atlas Records: 61
Status: Uncommon in the Melbourne area.
Distribution: Restricted to drier habitats of the forested foothills.

Egernia whitii
Common Name: White's Skink
Atlas Records: 78
Status: Uncommon in the Melbourne area.
Distribution: Restricted, generally occurring in the dry forests of the foothills with rare occurrences in riparian and floodplain habitats of the western plains. Also occurring in rocky habitats.

Eulamprus tympanum
Common Name: Southern Water Skink
Nomenclature: Previously included as part of *Sphenomorphus tympanum* (Cogger *et al.* 1983), referred to as *S. tympanum* Cool Temperate Form (Jenkins and Bartell 1980), divided into the two species *Eulamprus tympanum* and *E. heatwolei* by Wells and Wellington (1984).
Atlas Records: 192
Status: Uncommon in the Melbourne area.
Distribution: Widespread species throughout most of the study area although generally confined to damp habitat types. Rarely recorded from the western basalt plains where it is confined to riparian and escarpment habitats.

Lampropholis delicata
Common Name: Delicate Skink
Nomenclature: Previously included in genus *Leiolopisma* (e.g. Jenkins and Bartell 1980), revised by Greer (1974).
Atlas Records: 122
Status: Uncommon in the Melbourne area.
Distribution: Widespread species occurring throughout the east and north of the study area but absent from the western basalt plains.

Lampropholis guichenoti
Common Name: Common Garden Skink
Nomenclature: Previously included in genus *Leiolopisma* (e.g. Jenkins and Bartell 1980), revised by Greer (1974).
Atlas Records: 518
Status: Common in the Melbourne area.
Distribution: Widespread throughout most of the study area except the western basalt plains where it is uncommon and confined to woodland vegetation in riparian and floodplain habitats.

Lerista bougainvillii
Common Name: Bougainville's Skink
Atlas Records: 128
Status: Uncommon in the Melbourne area.
Distribution: Generally occurs in the drier habitats of the plains and the dry open forests of the foothills. Recorded in rocky outcrops and stony rises.

Nannoscincus maccoyi
Common Name: McCoy's Skink
Atlas Records: 81
Status: Locally common.
Distribution: Restricted, confined to damp sclerophyll forests of the uplands. Occurs in damp detritus of leaf litter and rotting logs on the forest floor.

Niveoscincus coventryi
Common Name: Coventry's Skink
Nomenclature: Previously referred to as *Leiolopisma coventryi* (Cogger *et al.* 1983); included in genus *Pseudemoia* by Cogger (1992); revised by Hutchinson *et al.* (1990).
Atlas Records: 32
Status: Rare in the Melbourne area.
Distribution: Occurs in the forested habitats of the foothills and uplands. Rare in the study area but relatively widespread and common in adjacent regions such as the South Gippsland Plains (Andrew *et al.* 1984).

Niveoscincus metallicus
Common Name: Metallic Skink
Nomenclature: Previously referred to as *Leiolopisma metallicum* (Cogger *et al* 1983); included in genus *Pseudemoia* by Cogger (1992); revised by Hutchinson *et al.* (1990).
Atlas Records: 5
Status: Rare in the Melbourne area.
Distribution: Restricted, occurs in a variety of habitats in the south-eastern plains. Common and widespread in the adjacent Western Port region (Andrew *et al.* 1984). Occasional records from coastal and grassland areas in the plains to the south-west of the study area are unusual and may warrant further investigation.

Pseudemoia entrecasteauxii
Common Name: Southern Grass Skink
Nomenclature: Previously included in *Leiolopisma entrecasteauxii* (Cogger *et al.* 1983); referred to as *Leiolopisma entrecasteauxii* Form B (Jenkins and Bartell 1980); referred to as *Leiolopisma entrecasteauxii* Group 2 (Donnellan and Hutchinson 1990); referred to as *Pseudemoia entrecasteauxii* Group 2 (Hutchinson *et al.* 1990); revised by Hutchinson and Donnellan (1992).
Atlas Records: 20 (records registered as *Leiolopisma entrecasteauxii* Form B only).
Status: Generally uncommon to rare in the Melbourne region, although locally common in restricted areas.
Distribution: Widespread, occurring throughout the eastern half of the study area in forested habitats characterised by an understorey supporting both woody shrubs and grasses. Absent from the treeless grassland habitats of the western plains.
Notes: Morphologically similar to *Pseudemoia pagenstecheri* and *P. rawlinsonii*. There are 210 records of *Leiolopisma entrecasteauxii* on the Atlas of Victorian Wildlife which represent either *P. pagenstecheri* or *P. entrecasteauxii* and are not included in the above tally. *P. pagenstecheri* and *P. entrecasteauxii* were both previously referred to as the Grass Skink.

Pseudemoia pagenstecheri
Common Name: Tussock Skink
Nomenclature: Previously included as part of *Leiolopisma entrecasteauxii* (Cogger *et al.* 1983); included as part of *Leiolopisma entrecasteauxii* Form A (Jenkins and Bartell 1980); referred to as *Leiolopisma entrecasteauxii* Group 1 (Donnellan and Hutchinson 1990); included as part of *Pseudemoia entrecasteauxii* Group 1 (Hutchinson *et al.* 1990) revised by Hutchinson and Donnellan (1992).
Atlas Records: 252 (records registered as *Leiolopisma entrecasteauxii* Form A only).
Status: Locally common.
Distribution: Restricted, occurs in tussock grasslands and grassy woodlands of the newer volcanic plains.
Notes: The most commonly encountered reptile in some areas of the western volcanic plains. A highly variable species which may be confused with *P. entrecasteauxii* and *P. rawlinsonii*. There are 210 records of *Leiolopisma entrecasteauxii* on the Atlas of Victorian Wildlife which represent either *P. pagenstecheri* or *P. entrecasteauxii* and are not included in the above tally. *P. pagenstecheri* and *P. entrecasteauxii* were both previously referred to as the Grass Skink.

Pseudemoia rawlinsonii
Common Name: Glossy Grass Skink
Nomenclature: Previously referred to as *Leiolopisma entrecasteauxii* Group 3 (Donnellan and Hutchinson 1990); described as *Leiolopisma rawlinsonii* (Hutchinson and Donnellan 1988) revised by Hutchinson *et al.* (1990).
Atlas Records: 19
Status: Rare in the Melbourne region. Listed as 'Insufficiently Known' (suspected Rare, Vulnerable or Endangered) in Victoria (Baker-Gabb 1993).
Distribution: Occurs in swamp habitat of floodplain, wetlands and riparian zones.
Notes: Morphologically similar to *P. entrecasteauxii* and *P. pagenstecheri*.

Pseudemoia spenceri
Common Name: Spencer's Skink
Atlas Records: 9
Status: Rare in the Melbourne area.
Distribution: Restricted, occurs only in the north-west of the study area in damp sclerophyll moist hillslope and dry foothill forest.

Saproscincus mustelinus
Common Name: Weasel Skink
Nomenclature: Previously included in genus *Lampropholis* (e.g. Cogger *et al.* 1983), revised by Wells *et al.* (1984).
Atlas Records: 161
Status: Common in the Melbourne area.
Distribution: Restricted, occurs in the damp sclerophyll forests of the uplands and damp riparian and woodland forests of gullies in lowland areas. Absent from the western basalt plains. Often occurs in gardens in the outer eastern suburbs of Melbourne.

Tiliqua nigrolutea
Common Name: Blotched Blue-tongued Lizard
Atlas Records: 111
Status: Uncommon in the Melbourne area.
Distribution: Generally confined to the forested habitats of the foothills and uplands in the east. Absent from the volcanic plains. Common and wide-spread in the adjacent Western Port region (Andrew *et al.* 1984).
Notes: Records registered as '*Tiliqua* sp.' on the Atlas of Victorian Wildlife are not

included in the above total number of records.

Tiliqua scincoides
Common Name: Common Blue-tongued Lizard
Atlas Records: 362
Status: Common in the Melbourne area.
Distribution: Widespread, occurs in the grasslands and grassy woodlands of foothills and newer volcanic plains, mostly in the west and north of the study area.
Notes: Records registered as '*Tiliqua* sp.' on the Atlas of Victorian Wildlife are not included in the above total number of records. Also known as the Eastern Blue-tongued Lizard.

Trachydosaurus rugosus
Common Name: Stumpy-tailed Lizard
Atlas Records: 3
Status: Introduced to the Melbourne area.
Distribution: Victorian distribution includes areas north of the Divide and the south west of the state. Rarely seen in the Melbourne area. Also known as Stump-tailed Lizard, Shingleback or Shingle-back.

FAMILY ELAPIDAE

Austrelaps superbus
Common Name: Lowland Copperhead
Nomenclature: The species referred to as *Austrelaps superbus* in Cogger *et al.* (1983) has been recognised since 1969 as consisting of two distinct forms: a montane form and a lowland form originally described by Rawlinson (1969). The two forms were described as separate species, *A. superbus* and *A. ramsayi*, by Rawlinson (1991).
Atlas Records: 193
Status: Uncommon in the Melbourne area.
Distribution: Occurs on the timbered hill-slopes and plains, often associated with wetland or riparian habitats. Probably absent from the treeless grasslands of the western basalt plains.
Notes: This species was once widespread and common throughout the study area (Rawlinson 1965). The Highland Copperhead *A. ramsayi* occurs in the highlands east of Melbourne but does not occur in the Melbourne region.

Drysdalia coronoides
Common Name: White-lipped Snake
Atlas Records: 78
Status: Uncommon in the Melbourne area.
Distribution: Occurs throughout the study area in box woodland, riparian woodland and coastal heathland and coastal tussock grassland.

Notechis scutatus
Common Name: Tiger Snake
Atlas Records: 326
Status: Common in the Melbourne area.
Distribution: Occurs throughout the study area in a range of habitat types, often recorded in riparian and wetland habitats.
Notes: The most commonly encountered large elapid snake in the Melbourne area, although like the other large elapids in the study area, may be declining in numbers locally.

Pseudechis porphyriacus
Common Name: Red-bellied Black Snake
Atlas Records: 39
Status: Regionally rare - locally extinct.
Distribution: Absent from much of the study area with most recent records being from the volcanic foothills of the uplands and the plains of the north-east region.

Pseudonaja textilis
Common Name: Eastern Brown Snake
Atlas Records: 179
Status: Uncommon in the Melbourne area.
Distribution: Occurs throughout the study area in a range of habitats excluding damp sclerophyll and montane forests. Rarely recorded in the South Gippsland plains, but occurs south of the study area in forested habitats of the Mornington Peninsula.
Notes: Juveniles can be superficially confused with the Little Whip Snake *Suta flagellum.*

Rhinoplocephalus nigrescens
Common Name: Eastern Small-eyed Snake
Nomenclature: Previously referred to as *Cryptophis nigrescens* (Cogger *et al.* 1983); revised by Hutchinson (1990).
Atlas Records: 38
Status: Uncommon in the Melbourne area.
Distribution: Restricted, inhabits the dry forested hillslopes of the north and east of the study area.
Notes: Cryptic species rarely encountered.

Suta flagellum
Common Name: Little Whip Snake
Nomenclature: Previously referred to as *Unechis flagellum* (Cogger *et al.* 1983); new name used by Cogger (1992) and Hutchinson (1990).
Atlas Records: 228
Status: Locally common.
Distribution: Restricted, occurs in grassy ecosystems, grasslands and grassy

woodlands of the newer volcanic plains where it is often associated with rocky outcrops, rock fences, stony rises and escarpments.

Acknowledgements

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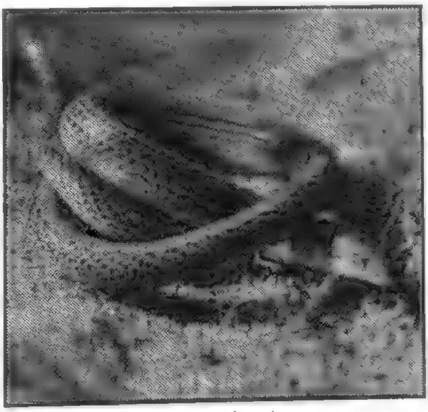

Striped Legless Lizard *Delma impar*.
Photo. by S. Larwill.

Discovery of a Cleistogamous Form of Clover Glycine in the Arthur's Seat State Park

Stefanie Rennick[1]

Clover Glycine *Glycine latrobeana* is a decumbent leguminous herb that is listed as vulnerable in Victoria and rare Australia wide.

On the Mornington Peninsula it is known with certainty from only one location, at the Arthur's Seat State Park, where it is scattered over about 0.4 ha of open grassy forest infested with Boneseed *Chrysanthemoides monilifera*.

The plants were discovered in October 1987 by a member of The Field Naturalists Club of Victoria (FNCV) some time after he had cleared a dense stand of the introduced weed, Boneseed. His attention had been drawn to the colourful purple flowers (Fig. 1). The location is adjacent to a plot where the FNCV remove Boneseed annually and is within a quadrat being monitored by the Botany Group of the club.

Glycine latrobeana typically has erect flowering stems up to 14 cm tall with silky, appressed hairs and with a short terminal spike of showy purple and green, shortly-stalked to stalkless pea flowers. The flowers are about 15 mm across and produce pea-shaped pods after fertilisation. (These showy open flowers are known as chasmogamous flowers). However, in spring 1994 no such flowers appeared, although numerous pods were noted, apparently developing directly out of the leaf axils (Fig. 2). Investigations at the National Herbarium of Victoria revealed that those pods had developed from tiny self-pollinating cleistogamous flowers, i.e. flowers that do not open to expose their reproductive parts, thereby preventing cross pollination. These cleistogamous flowers are green and globular, about 1 mm in diameter and are enclosed in broad hairy bracts within the leaf axils.

This flower form apparently has been overlooked by Victorian botanists, although examination of specimens at the National Herbarium revealed a number of plants from

Fig. 1. The original specimen of *Glycine latrobeana* with chasmogamous flowers collected by Tom Sault, Arthur's Seat, October 1987. (Sketch by Stefanie Rennick).

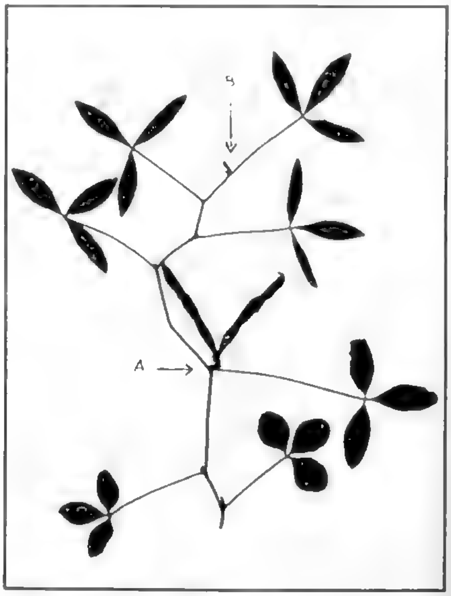

Fig. 2. *Glycine latrobeana* with seed pods that developed from cleistogamous flowers. (A.) Open pods seeds dispersed. (B.) Tiny emerging pod. (Photocopy of a pressing from Arthur's Seat State Park Herbarium).

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various locations with cleistogamous flowers. This discovery demonstrates what interesting finds can be made when participating in botanical monitoring, habitat restoration and propagating work.

It is reported that cleistogamous flowers can be produced by many plants in response to adverse environmental conditions. It would be interesting to investigate why the Arthur's Seat plants are producing cleistogamous flowers despite the removal of the competing Boneseed plants and to record how frequently cleistogamous and 'standard' chasmogamous flowers are produced (Fig. 3).

Acknowlegements

I would like to thank: John Eichler for helping me produce this article; Bob Parsons and Neville Scarlett of La Trobe University for so promptly sending me valuable information on the Glycine; The National Herbarium, Melbourne for permitting me to view their Glycine specimens, dating back to the last century; Tom Sault who, in the first place, made us aware of this interesting Glycine on Arthur's Seat and Ilma Dunn for photographing it in situ for our book 'The Mornington Peninsula, A Field Guide to the Flora, Fauna and Walking Tracks'.

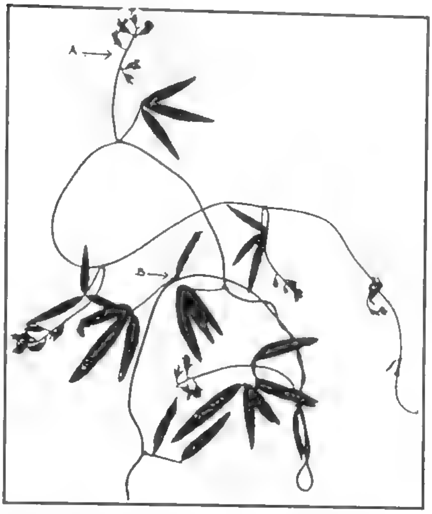

Fig. 3. *Glycine microphylla* showing (A.) chasmogamous flowers and (B.) cleistogamous pods. (Photocopy of a pressing from the Arthur's Seat State Park Herbarium. Specimen collected by Ilma Dunn, Greens Bush, 24 November 1988).

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Books Available from FNCV

The Club has, over the years, published a number of books on natural history topics which can be purchased from the Book Sales Officer. It is currently distributing four, as follows:

'What Fossil Plant is That?' (J.G. Douglas) $12.50
A guide to the ancient flora of Victoria, with notes on localities and fossil collecting.

'Wildflowers of the Stirling Ranges'. (B. Fuhrer and N. Marchant) $7.95
144 magnificent illustrations of the spectacular flora of this region.

'Down Under at the Prom'. (M. O'Toole and M. Turner) $16.95
A guide to the marine sites and dives at Wilson's Promontory (with maps and numerous colour illustrations).

'A Field Companion to Australian Fungi'. (B. Fuhrer) $19.95
A reprint of the earlier book with additional photographs and incorporating name changes.

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Searching for the Rare White Bird

Glen Jameson[1]

If Dreaming places collect power through the stories that are generated by their spirit, then perhaps the Glynns property comes close to being the White Cockatoo Special Place.

They sweep through the Gorge valleys and across the river flats in ecstatic, shrieking clouds. An amorphous white mass moving like crazed mist above the muddied waters of Birrarrung, the Yarra Yarra. In numbers of over one hundred, they replace the small bird chatter and hypnotic chime of the Bell Miner with raucous song and chorus of the day's events. Piercing chants of Cocky lore break the skies. Sometimes the sound that they generate rises to such levels, that it can challenge the noise coming from the cars along Warrandyte roads; quite a splendid effort.

It is reminiscent of the intense sound levels generated by Magpie Geese, *Anseranas semipalmata*, on Wetlands at Kakadu, but they haven't always been in such a position of strength. In the early 1980's, the Sulphur-crested Cockatoo, *Cacatua galerita*, numbered perhaps a dozen or so birds in the forests around Warrandyte, having gone through an intensive recent history of persecution and casual slaughter. It was the incorporation of the Glynns property (soon to be named Laughing Waters Park) into the Yarra Valley Parks, a Melbourne Parks and Waterways park, around this time that gave them a safe refuge and the opportunity to still call Australia home.

Observing the changes that come to an area set aside as a Sanctuary such as the Glynns property, illustrates how the Flora and Fauna can recover when given the opportunity. Glynns is at the upstream end of the Yarra Valley Park. It is the land that is enclosed by the next river meander, immediately down stream from the Pound Bend. You see it across the river from the Pound Bend Picnic Reserve looking westward. The shapes in the river that create Pound Bend also create the biggest incised meander in the Australian river systems; the Glynns meander contributes to this extra-ordinary geological wonder. An incised meander is one where the river has maintained its general course over a section of land during a period of geological uplift, with the river incising its way down through the parent rock material to keep on its original course.

The theme of this story centres on three species of White Birds (well, almost white), Sulphur-crested Cockatoo, Australian White Ibis (previously Sacred Ibis) *Threskiornis molucca*, and the white form of the Grey Goshawk, *Accipiter novaehollandiae*. It is not the full story of all that has happened on the Glynns property, but a selective vertical slice of observations from the past ten years.

It is late afternoon, one warm and balmy day just on the 1993 summer solstice and the first few Silent Scouts of the White Cockatoos glide over the Warrandyte Tunnel, cross the river and fly into Glynns. They follow the downstream flow of the River and move to strategic vantage points, commanding views up and down the River Valley. A little while later, the first of the Proclaimers leading the Cocky Mob follow the same path with exalted, loud and confident voices, calls that carry for a surprising distance. They are calls made by those unafraid of who hears the Big White Parrot. Their resonance stamps the ground as Cocky Country.

Those Birds whose responsibility it is to keep watch from the ridge country, depart from the main Mob and effortlessly slip across the high ridges to carry out a patrol of the next valley. All the while that highly communicative voice of each individual, sending information back to the Mob who are now tentatively roosting on a massive Manna Gum *Eucalyptus viminalis*, overlooking the Wetlands and River at the bottom of the property in the south-west corner.

[1]Longridge Farm, Warrandyte, Victoria, 3113.

The collective knowledge of the 100 or so Cockies that make up the Glynns Mob must be immense. Individual birds have been known to live to one hundred years old. They are strong fliers who can cover large areas in an attempt to satisfy their insatiable curiosity, those black eyes shining with wisdom and mischief, scanning the forests and streets for news and opportunity.

In a Yellow Box, *Eucalyptus meliodora*, across the river from Glynns, at the bottom of Longridge (also Yarra Valley Park lands), are a small group of Yellow-tailed Black-Cockatoos *Calyptorhyncus funereus*. The younger Black Cocky birds, as usual are cawing to the parents, w hose call is a gentle whistling when compared to the White Cockies. A White Cocky Patrol of angry young Turks discover the Black Cockies and immediately descends upon them in a fierce attack. The Black Cockies are panic struck, two bolt down the river and the other five birds haphazardly make their way to another large tree nearby. The Black Cockies remain there, totally shattered and uncharacteristically quiet, for the rest of the early evening. Meanwhile outraged Patrols of White Cockies speed up and down the river, screaming out warnings and threats to any others who may be lurking on their Trees, now strangely leaving the Black Cockies to themselves. The Black Cockies regroup and later slip off under the cover of night, wishing to avoid any more unpleasant confrontations.

The drama subsides, another story to be re-enacted out in front of the Cocky Mob on the Manna Gums. The river meander resounds to the screeching howls and hoots of territorial superiority. From the top of the high ridge at Longridge members of the Trick Cockie Troupe take advantage of the steep slope to aerially dive and soar down at terrific speed. Half way down the slope, they turn upside down, twist and weave in spectacular aerobatic displays. It is breathtaking larrikin showoff bravado at its best and the crowd on the Manna Gums just about do the Mexican Wave in appreciation. The summer is theirs.

Early autumn and the White Cockatoos, reminiscent of grazing sheep, wander in a huge flock across the elevated river terrace, digging and eating Onion Grass *Romulea rosea* and Sour Sob *Oxalis pescarpe* corms. They must consume vast amounts of these weeds in search of the carbohydrate stored in the corms. Late afternoon is spent back on the big Manna Gums *Eucalyptus viminalis*, a tribe in each tree, where continued and sporadic disturbance sends one group or another up into the air to slowly flutter, circle and then return to roost. They are the image of those wonderful tourist mementos; plastic 'snow domes' encapsulating your favourite destination, that silently float fake snow through the water when you shake them.

It is now early spring, a week after the 1994 equinox. The dry conditions inland have begun to bring interesting visitors and extended the stay of migrating regulars such as the big mob of Australian White Ibis and Staw-necked Ibis, *Threskiornis spinicollis*, of which at least two hundred birds have been at Glynns from early winter.

The Ibis mobs' favourite overnight roosts are the massive Manna Gums overlooking the river in the south-west corner of Glynns. Previously the favourite roost of the Sulphur-crested Cockatoos, who are so severely crest-fallen they have barely raised a scrawk since the Ibis moved them on.

The occupation of the site by the Ibis could not be in more contrast with the previous reign of the White Cockies. The Ibis return to their roosts in Glynns in the dusking early evening, after a full days honest slog in the wet meadows and swamps feeding on insects. None of this turning up mid-afternoon like larrikin Cockies full of bragging wind. The Ibis stream into Glynns with meticulously ordered flight patterns, awesome, immaculate lines that enthralled Pharoahs and still generate an aura of timeless antiquity. Demure honking of the Ibis is faintly heard on the breezes, from a distance it can barely be heard at all.

The Ibis flight path usually follows the river as they return from the extensive Billabong and Wetland system of the Yarra Flats (Heidelberg and Ivanhoe), downstream. As their stay lengthens due to dry inland conditions, the Ibis come from more disparate directions, Kangaroo Ground, Eltham and Panton Hills.

Finally, one night in late October, as the Ibis arrivals at Glynns started to become more irregular, they showed their dry sense of humour when a few late arrivals to the roost, parodied the Trick Cocky Troupe by doing a couple of 'upside -downers' coming in to land. It must have kept the whole Ibis mob in quiet, honking laughter all night each time they thought of it. The White Cockies detested them.

Disgruntled, the White Cockies kept to the eastern end of Glynns and bided their time, summer had to come and the Ibis had to eventually leave.

Do the Cockies pose a management problem due to their dominating numbers? Are they a positive for Park management or do they threaten other wildlife and the health and integrity of the remnant Bushlands? They have been observed locally harassing Wedge-tail Eagles *Aquila audax*, Whistling Kites *Milvus sphenurus* and of course the Yellow-tailed Black-Cockatoos. Could they be over-harvesting local Eucalypt and other remnant Bushland seed?

The overclearing for agriculture that has previously occurred on Glynns (and the surrounding residential areas) and the resulting unbalanced ecosystem has created an ideal situation for the explosion of their numbers to occur. The Cockies, who prefer open lightly forested habitats, are behaving like classic colonisers taking advantage of a vacuum, a niche that must be filled. Colonisers invade in waves of succession, just as Cassinias, Wattles and Wallaby Grasses do in some cases in the plant world. Niches that get filled and then succeeded by another assemblage of organisms as conditions change due to the effects of the colonisers' life cycles. This is what we are observing, a vital stage in the initial phase in the restoration of the urban Wilderness. As the revegetation fills out and other Fauna find Glynns, it will become a less attractive habitat to the White Cockies who will be less able to dominate the site. Once the Glynns Wetlands becomes a suitable site for the Ibis to breed they may have a resident mob who will make it even more uncomfortable for the White Cockies. The Cocky Mob may have helped to establish a small group of Long-billed Corellas, *Cacatua tenuirostris*, who have been in residence for the past years. Even a cage-escaped Major Mitchell Cockatoo *Cacatua leadbeateri* flew with the Cockies a few years ago, until apparently falling prey to the Whistling Kites, who also use Glynns.

What is apparent is that when we also consider the recruitment and generation of other Wildlife within Glynns, the power that 'Sanctuary Areas' have in restoring the ecology, is immense and of the greatest importance to the Urban Wilderness.

The high numbers of Sulphur-crested Cockatoos may be antagonising the local human community. Damage that they can do to fruit and nut trees and, in some cases, to timbers on houses and the racket they make, can make them unpopular and an unwelcome fauna for some parts of the local human community. Park management may be seen as not being fair and reasonable managers of Wildlife to allow numbers to become greater and may get the local community offside. However, it is up to Park Management to continue the educative process in the manner that the ParkCare programme formalised and persuade those parts of the community who may be negatively inclined, that we all have to make allowances in the process of environmental reconciliation.

There have not been many recordings of the white form of the Grey Goshawk in the middle Yarra region. It is an uncommon and mysterious visitor/vagrant, probably coming in during hard times elsewhere and this, 1994, was the year for it. The white form of the Grey Goshawk (the other form is, surprisingly, very grey) is the dominant form of the bird around the coast of Victoria, in Tasmania and over in the Kimberley region. One of the preferred habitats of the White Goshawk is heavily timbered edges of water courses. The bird is reputedly a particularly powerful, highly skilled hunter and I caught sight of it near the Annulus Billabong (Yarra Flats Park, Ivanhoe) in April 1994, at first thinking it to be a White Cockie because of the size of its wings. A good view of it as it sat calmly whilst we scrutinised its details, confirmed it as the white form of the Grey Goshawk, probably a female which is the larger of the sexes. Observations of probably the same bird or perhaps its partner, were made in Warrandyte and on the Yarra Flats during winter and a later springtime observation of the bird calling from the large Sugar Gum that rises above the canopy on the crest of the Glynns hill.

The white form of the Grey Goshawk was recorded at Glynns around the summer solstice of 1994 and there is speculation that it may be breeding locally. Would it breed so far from its territory? Would it take up permanent residence? Glynns certainly provides opportunities that make it attractive for the Goshawk to stay. They have been known to fly with flocks of White Cockies, using them as camouflage to take smaller birds who haven't noticed the slightly different bird in the flock. The mix of open grassy areas, regenerating slopes, dry sclerophyll hill country and the riparian forest, river and wetlands generates a wide variety of prey and habitat. It is these qualities that create biological opportunity and give importance to an area such as Glynns, especially in a regional context, providing refuge in times of environmental stress in other parts of the State.

It is the thrill of seeing the rare white bird finding and using these resources that is a reward for all the planning and work needed to restore the urban wilderness. It is a benchmark of the success of the Park vision to record a rare white bird as part of the fauna.

Acknowledgements

I wish to thank Patrick Fricker for his encouragement, vision and for playing 'cockatoo' for the Yarra Valley Environment.

The Wasp and the Spider

Angus Martin[1]

In a garden in Camberwell at midday on 3 April 1995 I was casually observing the web of a Leaf-curling Spider *Phonognatha graeffei*; the web was in good repair. A spider (assumed, and later proved, to be a female) was in the curled leaf at the hub of the web; her legs were visible at the entrance. A European Wasp *Vespula germanica* landed at the hub of the web on the opposite surface from the leaf retreat. After a few moments the wasp left, to return about two minutes later. This time she forced her way through the web and immediately entered the leaf retreat. After about 1.5 minutes she left, to return yet again after another short interval. Now she landed on the same side of the web as the retreat and re-entered it. For the following 2.5 minutes neither spider nor wasp was visible, but the retreat shook and vibrated intermittently. The wasp then re-emerged tail-first, carrying the spider's abdomen, which she dropped (presumably not intentionally) just after leaving the retreat (hence enabling the abdomen to be retrieved and identified).

I then removed the retreat from the web and carefully opened it. Fresh spider remains - part of a cephalothorax and about 15 leg fragments - were contained in the retreat.

This observation shows that European Wasps have developed the capacity to exploit a presumably novel food-source (there are no Leaf-curling Spiders in Europe), utilising a feeding technique which discards all but the nutritionally-rich abdomen of the spider. Clearly neither the spider's web, nor its venom, nor its use of a retreat which is usually regarded as a refuge from predation, offered any effective defence against this exotic predator, even though the cavity within the leaf was so narrow that the wasp obviously did not have room to deploy her sting. Since both wasp and spider are most active in later summer and autumn, and since the spider seems to be so vulnerable to wasp predation, I cannot but feel some concern over the survival prospects of the Leaf-curling Spider in areas supporting dense European Wasp populations.

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From our Naturalist in Residence, Cecily Falkingham

Those Magical, Mystical Creations - Galls

I wonder how many people, when walking in the bush, are aware that those strange, sometimes exotic-shaped creations seen on plants can tell a tale of mystery and intrigue comparable to any fairy story or science fiction invention.

My fascination with galls started ten years ago when I collected my first gall, after years of wondering exactly what they were! I unsuccessfully tried to raise to maturity the tiny insect inside the gall. In my ignorance I had tried to do this by placing the stem of the eucalypt leaves, on which the gall grew, into a jar of water. The gall withered and died without the normal supply of nourishment flowing through trunk, stem and leaves, as well as an absence of sunlight which provides both carbohydrates and warmth for the tiny inhabitant.

With a small home-made low-powered microscope (10 x) a world of bizarre-shaped insects housed in even more bizarre-shaped galls aroused such curiosity and wonder, I am still hooked on galls.

The wonder of personal discovery is always so much more exciting than reading facts from books. I actually discovered facts about their life cycles long before I read about them.

On the stems of Hop Goodenia *Goodenia ovata* grew an oval-shaped, 1.5 cm, pale mauve/green gall - the *Goodenia ovata* Gall (Fig. 1). Closer examination revealed a tiny brown empty pupal case or in some cases a minute cream larva curled in perfect safety in its well-camouflaged home.

I then discovered the Nematode Gall, where the combined action of nematodes (*Fergusobia*) and a tiny fly larvae (e.g. *Fergusonina nicholsoni*) create many galls on leaves, stem tips, leaf and flower buds of eucalypts; the female fly larvae become infested with female nematodes which are then deposited in the eucalypt tissue with the fly eggs and both fly and nematode develop together in the gall, eventually leaving their gall home through many holes seen on the outside of the gall (Fig. 2).

Golden Bush-pea *Pultenaea gunnii* yielded more questions when I discovered what looked, at first glance, like a cluster of

Fig. 1. The Hop Goodenia *Goodenia ovata* Gall. *Photo. A. Farnworth*

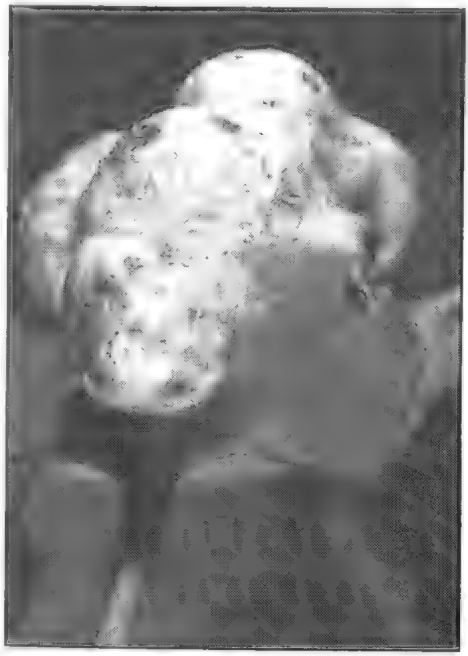

Fig. 2. The Nematode Gall. *Photo. A. Farnworth*

new growth or a mutation of the flower (Fig. 3). However, careful dissection with a sharp razor blade revealed the minute larvae nestled inside the intricate structure.

I discovered that each gall shape indicated the insect family involved and that galls grow on buds, leaves, stems, flowers and developing fruit. The Banksia Mite Gall causes large misshapen brown powdery and rough-textured galls to develop over the outside of Banksia cones of several species. All this caused by a tiny microscopic mite. Then there is the remarkable Casuarina Gall which mimics the fruit of the plant.

I then found that there is an exception to every rule (just to keep us on our toes)! The Eriococcidae Galls on eucalypts had a different shape according to whether a male or female resided inside the gall. The female gall - a large, green, acorn-shape - usually had some male galls nearby and they were small, ruby-red and trumpet-shaped.

With this particular group I eventually had some success with rearing. After keeping the two galls (male and female) in a jar for some time I was able to observe the large, recumbent, mealy female with a 1.5 cm body entombed like an Egyptian mummy and, swarming all over her, dozens of tiny microscopic bright-yellow insects with large black eyes, six legs, tiny feelers and covered in hairs. I had noticed, some days before the 'birth', tiny feathery appendages waving outside the tiny hole in the large gall. Was she signalling for a mate? The males had emerged from their trumpet-shaped galls as tiny 2.5 mm orange, pale-winged insects with the same mealy powder on their bodies and were jetting around the jar where the female continued to wave her feathery plumes. Who needs television with all this action, romance and intrigue!

Fig. 3. Gall on Golden Bush-pea *Pultneaea gunnii*
Photo. A. Farnworth

After reading some of the short passages about galls in many books, I learned that gall makers can be Gnats, Midges, Psyllids, Weevils, Coccids, Flies, Thrips, Beetles, Mites, Nematodes, Bacteria, a few moth species and Fungi. The latter causing those large, knobbly, protuberant lumps on Cherry Ballart *Exocarpos cupressiformis* and *Acacia* species.

I found that at least two gall-producing insects had been introduced: one, a Mexican species of fly *Procecidochares utilis* to control Crofton Weed *Ageratina adenophora* and two, the Gall Gnat, *Zeuxidiplosis giardi* to control St John's Wort *Hypericum perforatum*. This also points to yet another interesting fact that perhaps the many varieties of galls play a role in providing a control over seed production and growth generally in plants and possibly exerting some control of over-population.

So What are Galls?

They appear to be an abnormal growth produced when an insect or mite introduces through saliva or chemical stem injection, a compound which influences the growth of plant cells. The complex and highly individual chemicals in the saliva or body liquid produce proliferation of plant cells and so triggering off the mechanism which forces the plant to house the egg.

When and Why do Some Animals Create Galls?

Most galls are produced in spring or early summer while plants are in active growth. The galls range from 30 cm x 10 cm (Weevil Stem Galls) to tiny pimples measuring a few millimetres e.g. 'Pimple Galls' which appear on some eucalypts and are made by a wasp from the family, Nonotontomerinae. Some of the largest galls I have seen were in Central Australia and called Bloodwood Apples. They grew on the eucalypts and were collected, roasted and eaten by the aboriginal people. In the desert, these large gall structures would have protected the animal inside against desiccation due to high daytime temperatures and hot winds, and from the freezing night temperatures.

Gall structures aid in insulation, protection from predators and provision of food. For a gall animal it would compare with us living in one room surrounded by an endless supply of growing food.

Some galls replicate in shape, colour and texture the fruit, buds and seed of the plant and in doing so provide excellent camouflage for the developing animal.

Many galls accumulate large amounts of sugars to support the growth of the larvae and some galls contain high amounts of tannic acid or protein and also carbohydrates such as starches. Galls have been used in medicine and as human and animal food; the Aleppo Oak Gall of Asia was once an important source of tannic acid, containing 65%, and the gall ink produced from Aleppo Galls was considered the best type of ink and imported into the USA for writing important documents, while the Gall, which contained high quantities of protein and carbohydrates, was fed to domestic animals.

Predators

They are not without enemies and control of galls is supplied by gall wasps, predatory mites, birds and human use and consumption.

With approximately 2,000 different species so far identified, you would think our knowledge was fairly complete. But it is not and on taking some of my specimens into the entomology section of the museum I was told that, although they can now identify many of the species, the mystery of their sometimes complicated life cycle has yet to be accurately described.

I would like to hear from anyone who has observed varieties of host plants, life histories and particularly predators, as these highly rich food parcels must surely be eaten by a range of animals, particularly birds.

List of useful books

'The Insects of Australia'. (1979). (CSIRO: Canberra).

'Australian Insects'. (1945). Keith C. McKeown. (Sydney & Melbourne Publishing Co Pty Ltd).

'Insects of Australia' (1980). John Goode. (Angus & Robertson).

'Insects'. (1966). Ross E. Hutchins.

'The Insect Book'. (1948). Walter W. Froggatt. (Shakespeare Head Press Pty Ltd).

'Insect Wonders of Australia'. (1944). Keith C. McKeown. (Angus Robertson P/L).

'An Introduction to Australian Insects. (1982). Phillip W. Hadlington and Judith A. Johnston. (New South Wales University Press).

'Friends and Foes of Australian Gardens'. (1980). F.D. Hockings. (Reed Publishing).

'Pests, Diseases & Ailments of Australian Plants'. (1986). David Jones and Rodger Elliot. (Lothian).

'The World of Insects'. (1977). Zanetti Adriano. (Sampson Low).

Cecily Falkingham
27 Chippewa Ave., Mitcham Victoria, 3132

The Silken Web: a Natural History of Australian Spiders

by Bert Simon-Brunet

Publisher: *Reed Books, Sydney, 1994.*

208 pp. RRP $39.95 (hb).

For reasons that are not entirely clear, spiders have a bad press, and are consequently under-represented in the natural history literature. This is as true for Australia, which has an abundance of spiders, as for elsewhere in the world. Indeed, the last comprehensive book devoted to Australian spiders was Barbara York Main's volume 'Spiders', published by Collins in 1976 and now out of print. Thus, the publication of the present volume could not be more timely.

'The Silken Web' is divided into two parts. The first part outlines the general biology of spiders, including evolutionary origins, anatomy, habitat, predators, reproduction and the importance of silk. This account of spiders is generally accurate, although it is surprising that the results of recent studies are not included. A very substantial body of research has emerged over the last fifteen years, and yet 75% of the articles in the reference list were published before 1980.

In the second part of 'The Silken Web', Simon-Brunet divides the Australian spiders into the three major groups; the Mygalomorphs, Hypochilomorphs and the Araneomorphs. While the arrangement of these major groups is conventional, the Araneomorphs or modern spiders are arranged according to the ways in which they utilise silk to capture their prey, rather than to their taxonomic affiliation. Implicit behind this arrangement is the notion that these foraging strategies represent various evolutionary end-points which parallel the evolutionary radiations of the insects. Thus, the Araneomorphs are divided into open-range hunters, ambushers and anglers, apprentice weavers and master weavers. The open-range hunters rely on mobility, eyesight, strength and swiftness rather than silk to capture their prey, while the ambushers and anglers remain stationary in places where insects frequent, ambushing those hapless prey that venture within striking distance. The apprentice weavers build untidy, three dimensional silk snares that lack the characteristic symmetry of the webs of the master weavers. Several representative species from different families within each category are described, with details of their appearance, toxicity, danger to humans, habitat, distribution and reproductive behaviour.

This arrangement is not a bad idea because, in most cases, these different foraging strategies are closely associated with particular taxa. However, the chapter describing the ambushers and anglers seems unnecessarily arbitrary and may be confusing. The Crab Spiders (Thomisidae) are certainly ambushers; these impressively cryptic animals hide in flowers, where they capture unsuspecting pollinators or other insects feeding on nectar. But the behaviour of the Lobster-pot Spider seems more analogous to web-building species; this thomisid spider builds a rigid, silken nest that resembles a lobster-pot. Ants that venture into these pots are then caught by the spider sitting at the base of the pot. The chapter also includes those web-building spiders that do not build conventional orb-webs. Most familiar of these spiders is the moth-attracting Bolas Spider, which captures its prey on a sticky bolas that the spider swings on the end of a silk line. The problem with this arrangement of the chapters is that it seems to obscure the fascinating evolutionary divergence, convergence and loss of different foraging strategies.

The text is easy to read and nicely enhanced by simple diagrams and a wonderful collection of excellent photographs. There are also some beautiful, large, full colour illustrations of several species. The main text is augmented by boxes that highlight particular species or unusual anecdotes about spiders. These visual aspects of 'The Silken Web' are superb, and surely confirm the beauty and fascination of many spiders.

However, a natural history book must also be judged by the accuracy of the text, and in this respect the book is a disappointment. Some anthropomorphisms can almost be forgiven, but not if they are based on erroneous generalisations. Male spiders of sexually cannibalistic species may well experience fear; we'll never know. But it is unlikely that all male spiders are in fear of their lives from rapacious females, because sexual cannibalism is common in only three or four families. More importantly, there are simply too many factual errors. For example, the ant mimic *Amyciaea albomaculata* is a thomisid not a salticid, and while the taxonomy of Australian orb-weavers is rather poorly understood, '*Araneus*' *bradleyi* does not belong in the genus *Eriophora*. Interestingly, we are told that the first Australian spider to be formally described was *Gasteracantha fornicata*, now known as *Aranea fornicata*. In fact, this spider was incorrectly placed by Fabricius in the genus *Aranea*, not the other way round.

Correct scientific names may not concern the general reader, but other errors might; it is certainly not clear that the white-tailed spider is responsible for necrotic sores, and the organism that causes ulcerating sores is a bacterium *Mycobacterium ulcerans*, not a virus called *Microbacterius ulcerans*. Spiders belonging to the genus *Myrmarachne* have a very close resemblance to ants, yet there are no records confirming the claim that these spiders prey on their ant models. Particularly irritating was Brunet-Simon's decision to re-name the webs built by araneid spiders 'wheel-webs' rather than the conventional 'orb-web'. Changing common names is confusing at the best of times, but there is insufficient reason to do so here. The word orb may give the impression of a sphere or globe, but it is derived from the Latin *orbis* meaning ring, which is an appropriate description of the web.

'The Silken Web' can be recommended for its illustrations, and maybe as a general introduction to spiders. The book will undoubtedly stimulate an interest in these fascinating creatures, perhaps even among arachnophobes. But the errors will spoil the book for experts, and generate confusion for those wishing to find out more. It is a great shame that it was not reviewed and edited more thoroughly before publication.

Mark A. Elgar and Rachel A. Allan
Department of Zoology,
University of Melbourne, Parkville, Victoria 3052.

Botany

John Eichler[1]

Activities

As a field naturalist with an interest in botany you will have the opportunity with the FNCV to participate in the following:

Regular field trips to the particularly varied vegetation communities found in the Melbourne region. Field trips generally deal with specific plant groups or vegetation communities and complement Botany Group meetings;

Organised surveys which include collecting data on the structural form of vegetation habitat preferences, species composition, frequency, and changes over time. Current projects include: ***A fungal survey*** at Wattle Park; ***Pre and post fire surveys*** at the Botanic Gardens Annexe, Cranbourne; ***Monitoring regeneration*** following Boneseed removal at Arthur's Seat, Dromana;

Collecting, preserving and identifying plant specimens (you will need a permit to collect on public land and permission from the owner to collect on private land);

Plant photography;

Workshops on plant identification, survey techniques etc. and field studies with expert speakers and guides;

Habitat restoration projects;

Preparing submissions on conservation issues, and

Regular meetings on a variety of topics catering for beginners through to experienced naturalists. Members are encouraged to contribute exhibits and nature notes, which are segments of each meeting. There is at least one Members Night a year at which members are invited to make a short presentation.

Equipment

A good **hand lens** of 10x magnification is essential to check details on which species identification is often based and to reveal the often hidden beauty of plants. A **stereo microscope** with magnification of 10x and 20x is a very useful piece of equipment but it is quite expensive and certainly not essential. (Much higher magnifications are needed when examining fungi).

A **plant press** is useful for drying plant specimens for identification at a later date and for preparing specimens for lodging at the National Herbarium. A press can be made from slats of wood nailed together in a lattice pattern to form 2 outer covers, each measuring approximately 50 cm x 30 cm.

If you wish to photograph plants you will need a **single lens reflex camera** that can be manually focussed, a set of **close-up lenses** or a **macro lens** and a **flash unit**.

You will want to apply names to the plants you find and to do this you will need some of the **books** listed below. To accurately identify those plants, it is necessary to learn some botanical terms and to use botanical keys. A number of the books listed below contain glossaries and keys.

Field Guides and Textbooks

General

Trees of Victoria and Adjoining Areas - L. Costermans. (Costermans Publishing). Excellent inexpensive introduction.

Native Trees and Shrubs of South Eastern Australia - L. Costermans (Lansdowne). Excellent colour photos and line drawings.

Flora of Melbourne - SGAP Maroondah Group. (Hyland House).

Census of Vascular Plants of Victoria - J. Ross. (National Herbarium of Victoria). Lists all currently recognised indigenous and introduced plants and gives current and former names.

Flora of Victoria - Vol 1 Introduction - D. Foreman and N. Walsh; *Vol 2 - Monocotyledons* - N. Walsh and T. Entwisle (Inkata) (Volumes 3 and 4, covering dicotyledon families, to be published March 1996 and September 1997). Comprehensive, up to date coverage with distribution information.

Collecting and Preserving Herbarium Specimens - D. Albrecht (National Herbarium of Victoria).

Specific Plant Groups

Ferns and Allied Plants of Victoria, Tas-

[1]18 Bayview Crescent, Black Rock, Victoria 3193.

mania and South Australia - B. Duncan and G. Isaac. (Melbourne University Press).

The Orchids of Victoria - G. Backhouse and J. Jeanes. (Miegunyuh Press).

A field companion to Australian Fungi- B. Fuhrer. (The Five Mile Press).

A Field Guide to Common Australian Fungi - T. Young. (NSW University Press).

Clubs and Societies

Indigenous Flora & Fauna Association.

Society for Growing Australian Plants.

Native Orchid Society.

Fern Society of Victoria.

Friends Groups associated with various nature conservation reserves.

Periodicals

Muelleria (a scientific journal published annually by the National Herbarium of Victoria).

Australian Plants (contains articles of general interest, including information on cultivation).

Answers in Nature Conservation (a scientific journal).

Indigenotes (contains articles of general interest).

The Orchadian (contains scientific articles, articles of general interest and information on cultivation).

Newsletters of relevant clubs and societies often contain interesting articles.

Enquiries

Your FNCV contacts for Botany are: John Eichler, phone: 03 598 9492 AH or write; Tom May, phone 03 655 2319 BH, 03 645 2381 AH or write to The National Herbarium, Birdwood Avenue, South Yarra, Victoria 3141. Tom and John will be able to answer many of your questions or direct you to others who can help.

Obituary

William Perry (1911-1995)

William Perry, who died in March 1995 at the age of 83, was born and lived all his life in Eaglehawk. In his youth he was an enthusiastic member of the Eaglehawk Rifle Club, and it was in their company that he first began to observe the plants of the bush. Gradually his interest in flora and fauna supplanted that in shooting and he became an acknowledged authority on the flora of the Bendigo Whipstick. He was also interested in the mining history of the area - his grandfather was manager of the South New Moon mine in Sailor's Gully - and in 1975 William published 'Tales of the Whipstick'.

He was elected as a country member of The Field Naturalists Club of Victoria on 8 June 1942 and three years later became one of the foundation members of the Bendigo Field Naturalists Club, and their first librarian. Between 1945 and 1969 William Perry contributed a number of articles and notes to *The Victorian Naturalist* and a glance at these indicates the breadth of his interest in natural history; birds, ants and spiders fascinated him, as well as orchids and acacias. He was also an accomplished photographer.

He was always ready to share his love of the bush and his knowledge of the Whipstick with visiting naturalists, particularly on excursions to the area by The Field Naturalists Club of Victoria.

In August 1982 the Bendigo Field Naturalists Club hosted the Victorian Field Naturalists Clubs Association weekend and it was at this gathering of his fellow naturalists from all over Victoria that William Perry was awarded the certificate of Honorary Membership of The Field Naturalists Club of Victoria, in recognition of his contribution to natural history over forty years' membership.

I am indebted to John Ipsen and Ray Wallace of the Bendigo Field Naturalists Club for much of the above information.

Sheila Houghton
Hon. Librarian, FNCV

The Field Naturalists Club of Victoria

In which is incorporated the Microscopical Society of Victoria
Established 1880

Registered Office: FNCV, c/- National Herbarium, Birdwood Avenue, South Yarra, 3141, 650 8661.

OBJECTIVES: To stimulate interest in natural history and to preserve and protect Australian fauna and flora.

Members include beginners as well as experienced naturalists.

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The Victorian Naturalist

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MEMBERSHIP

Members receive *The Victorian Naturalist* and the monthly Field Nat News free. The Club organises several monthly meetings (free to all) and excursions (transport costs may be charged). Research work, including both botanical and fauna surveys, is being done at a number of locations in Victoria and all members are encouraged to participate.

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MUSEUM OF VICTORIA
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since 1884

VALE MARIE ALLENDER

It is with deep regret that we report the death of Marie Allender on 27 September. Marie will be remembered for her long and dedicated service to the club and especially for her outstanding work in organising club excursions over many years.

NEW FNCV HOME

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Disclaimer from John Whinray

'A Census of the Plants of Deal Island, Kents Group, for 1884'

In 1993 the above paper was issued as my work in *The Victorian Naturalist*, **110** (6), 247-250. However, I neither saw nor approved the changed form in which it appeared. Given the standard of the changes, I would not have agreed to its publication. In so doing, I would also have mentioned the various typing errors, including the wrong dates.

I hereby disclaim the paper totally. It should never be referred to as my work. All members and subscribers should fully cross it out in their copies and indexes.

John Whinray,
Flinders Island, Tasmania.

Erratum

Index to Volume **111**, 1994 included in Volume **112** (3) 1995, should have included:

Jameson, G, 145

We extend our apologies to the author.

The Victorian Naturalist

F.N.C.V.

Volume 112 (5) 1995 October

Editors: Ed and Pat Grey

ISSN 0042-5184

Cover: Rodger Elliot, winner of the 1995 Australian Natural History Medallion (see article page 188).

Australian Natural History Medallion 1995
W. Rodger Elliot

Rodger Elliot needs no introduction to botanists and gardeners throughout Australia. Wherever people are interested in the growing of Australian plants his name springs to mind, not only as a provider of plants, but also for a great reference source, since the publication of the multi-volume 'Encyclopaedia of Australian Plants suitable for Cultivation' began in 1980.

Growing native plants has been Rodger's lifelong interest, inspired by an introduction to Australian flora while camping in the Grampians during his schooldays, and it is his understanding of the importance of environment to native plants which is significant in all his work. Influenced by Edna Walling, he abandoned his training as an industrial chemist, and in 1961 began work in the landscape firm of E.H. Hammond and Sons. From growing and propagating native plants in his parents' backyard, he progressed to the 'Austraflora' nursery, which he set up with his wife, Gwen, and which quickly became *the* Australian plant specialist nursery. In 1973 they transferred to the wholesale propagation nursery 'Australian Tube Plants' which has supplied plants to nurseries and floriculture industries in Australia, UK and USA. More recently, Rodger has become the plant expert in the 'Koala Blooms' company, which is developing a thriving export trade in Australian plants with the USA. The garden which he and Gwen established at Montrose, Victoria, has featured in a number of gardening magazines in Australia, England and USA.

Rodger has had a long association with the Society for Growing Australian Plants, Victoria, of which he and Gwen were made honorary life members in 1987. He was a founding member of the Society for Growing Australian Plants, Maroondah, in 1967 and has been involved in the Melbourne Wildflower Show, organised by this Group, since its inception twenty years ago, where his expertise in identifying specimens sent from all over Australia has contributed largely to making it such an annual success. He is a Fellow of the Royal Horticultural Societies of London and Victoria, an honorary life member of the Arboretum Associates, University of California, Santa Cruz, to whom he has supplied plants; the Australian Systematic Botany Society; the Bird Observers Club of Australia and is a past vice-president of the Ornamental Plants Collection Association for whom he holds the Dampiera Collection. In 1992 Rodger received the Australian Institute of Horticulture Award of Excellence and this year, the Australian Plants Award (Professional) from the Association of Societies for Growing Australian Plants.

Rodger is well-known as a lecturer and broadcaster. For eight years he ran courses for the Council of Adult Education and Monash University Summer Schools. He regularly gives lectures and demonstrations to the Victorian College of Agriculture and Horticulture, Burnley, and the Royal Botanic Gardens, Melbourne, as well as being in demand for talks to natural history societies. In 1988 he undertook a lecture tour in California and has led botanical tours to USA, Europe and China as well as nearer home to the Grampians.

He has travelled extensively throughout Australia on field collecting trips seeking not only plants with horticultural potential but also the rare and endangered species, so that stocks of these might be maintained. Many botanical gardens, here and overseas, research institutes and amateur enthusiasts have benefitted as a result of these expeditions. In 1991 he was invited to design a garden of eastern Australian plants at the Strybing Arboretum and Botanical Garden, San Francisco.

Rodger Elliot's career as an author began in 1972 with an article for *Your Garden* magazine and he became a monthly contributor for almost the next twenty years. In 1983 he began a series 'On Australian Plants' for the Royal Horticultural Society of Victoria's *Gardening News*. His love of the Grampians produced 'An Introduction to the Grampians Flora' (1975) and 'A Field Guide to the Grampians Flora' (1984). In 1984 the 'Plant Identikit' series, covering four significant botanical areas in Victoria, appeared, written by W.R. Elliot and illustrated by T.L. Blake. Three more booklets followed in 1988, covering areas in New South Wales. He has published a number of gardening books, but his major undertaking has been the 'Encyclopaedia of Australian Plants suitable for Cultivation', written in conjunction with David L. Jones. This unique work, still in progress, will cover the flora of the entire continent, providing a wealth of botanical information as well as practical assistance in growing Australian plants. To have been invited by a publisher to produce such a work is testimony enough to Rodger Elliot's standing in the botanical world. And as his wife, who has been involve in all his endeavours, has pointed out, 'the contributions Rodger is able to make are things he enjoys doing and which he feels have both value and purpose. There is no distinction between work and leisure' - and in this he is a fortunate man.

Rodger Elliot was nominated by the Society for Growing Australian Plants, Victoria, and all his work exemplifies their motto 'Preservation by Cultivation'.

Sheila Houghton

Australian Natural History Medallion

The Medallionist for 1995 is Rodger Elliot

His address will be 'Things which have caught my eye and other senses'.

The presentation will be made at the General Meeting of the club on 13 November in the presence of His Excellency, The Honourable Richard E. McGarvie, The Governor of Victoria.

The FNCV Council extends a warm invitation to all its members and their guests, and hopes that you will be able to attend such a prestigious event.

This award is presented annually to a person who can be shown to have increased popular or scientific knowledge of Australian Flora and Fauna, assisted notably in the protection or propagation of flora and fauna, discovered new species of importance, devoted much time to the study of the subject, done definite service by the publication of articles, books, photography and pictorial art, or by any other means. The FNCV is responsible for administering the award and bears the administrative expenses and the cost of the medallion itself, although two committees, the 'general' and the 'award', are responsible for the administration and selection of the medallionist.
The current medallion was designed by Tony Gilevski and is presented in a box made by Cameron Miller.

Reassessment of the Distribution, Abundance and Habitat of the Baw Baw Frog *Philoria frosti* Spencer: Preliminary Findings

Gregory J. Hollis[1]

Abstract

Reports of amphibian declines and extinctions are now numerous throughout the world. A number of these pertain to amphibian populations restricted to mountain-top environments in relatively pristine habitats. A survey was implemented to reassess the conservation status of the Baw Baw Frog *Philoria frosti* based on these reports and recent anecdotal observations that suggest a population decline in the species. Numbers of calling males counted in 1993 represent a decline by several orders of magnitude when compared with surveys of calling males conducted a decade ago. The habitats and microhabitats of calling males and oviposition sites appear different to former known breeding sites, being restricted predominantly to topographically protected gullies consisting of sub-alpine wet heath and montane riparian thicket vegetation. Potential reasons for this decline are considered and future research and management actions identified. A recently completed survey in 1994 confirms this apparent decline of the Baw Baw Frog population.

Introduction

The Baw Baw Frog *Philoria frosti* Spencer (Fig. 1) is the only amphibian endemic to Victoria (Hero *et al.* 1991) and is one of the most restricted amphibian species in south-eastern Australia, being distributed over an area of approximately 80 km² encompassing the Baw Baw Plateau, Victoria (Malone 1985a) (Fig. 2). It is considered to be vulnerable in Victoria (CNR 1993a) and also regarded nationally as a vulnerable species (ANZECC 1991).

Population surveys conducted in 1983 and 1984 estimated the number of adult males to be 10,000-15,000 (Malone 1985a). Based on this estimate, the status of the Baw Baw Frog has been presumed to be probably secure (e.g. Tyler 1992). However, in recent years anecdotal observations made by herpetologists and personnel of the Victorian Department of Conservation and Natural Resources indicate that numbers of calling males are significantly lower than that recorded by Malone (1985a) a decade ago. With increasing interest among both Australian and international biologists regarding a number of recent amphibian declines (e.g. Tyler and Davies 1985; Osborne 1989, 1990; Blaustein and Wake 1990; Watson *et al.* 1991; Mahony 1993; Richards *et al.* 1993) and extinctions (e.g. Barinaga 1990; Czechura and Ingram 1990; Osborne 1990; Phillips 1990), concerns were raised over the current conservation status of the Baw Baw Frog. Of even greater concern, a suite of species restricted to mountain-top environments and relatively pristine habitats, like the Baw Baw Frog, are among those that have declined or disappeared (see Osborne 1989, 1990, 1991; La Marca and Reinthaler 1991; Crump *et al.* 1992; Richards *et al.* 1993).

This paper presents the results of a survey for calling male Baw Baw Frogs conducted during spring and summer 1993. It documents the first part of a three-year survey program to monitor and research the species. Abundance, distribution and habitat data are analysed and compared with surveys conducted a decade ago (Malone 1985a). Also presented, are the results of a systematic survey for egg masses.

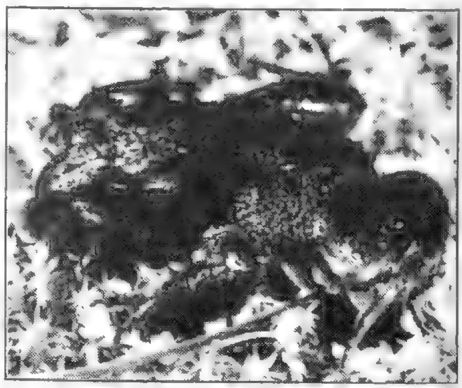

Fig. 1. Baw Baw Frog *Philoria frosti*, The Morass, Baw Baw Plateau, Victoria. *(Photo: Gregory J. Hollis).*

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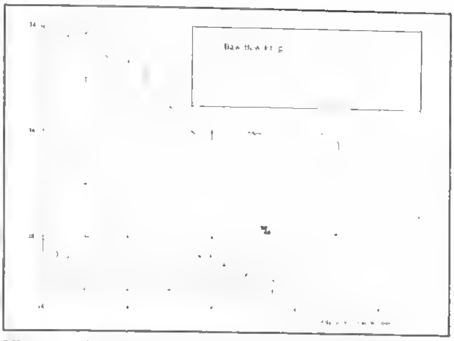

Fig. 2. Distribution of the Baw Baw Frog within five minute grids (Atlas of Victorian Wildlife)

Methods

Study area

The Baw Baw Plateau is located 120 km east of Melbourne and is primarily sub-alpine in climate; it receives a mean annual rainfall of 1500-2500 mm and mean annual temperatures range from 4-8° C, with July mean minimum temperatures of -2 - 0° C and February mean maximum temperatures of 11-13° C (Aldrick *et al.* 1992). From June to September snow may lie on the ground above approximately 1200 m.

Geologically, the Baw Baw Plateau consists of granodiorite (the Baw Baw batholith) with a zone of metamorphosed sedimentary rock (hornfels) surrounding the granodiorite (Douglas and Ferguson 1976). Geomorphology of the plateau includes a wide variety of features associated with the weathering of the granodiorite, including broadly concave valleys, peaty flats, tors, stepped-valley heads and a distinctive rectangular drainage pattern which is controlled by the rectangular pattern of joints in the granodiorite (Rosengren *et al.* 1981). Intermittent water courses drain the slopes of frost hollows into permanently flowing creeks within the larger valley flats, while ephemeral ponds often result from the accumulation of water in low-lying poorly drained areas. Soils on the plateau are characterised by: bog peats, restricted to the permanently wet bogs of sphagnum moss and hillside drainage lines; humified peats, found on the sloping edges of the bogs and in desiccating bogs on hillsides; transitional alpine humus soils and acid brown earths, occurring on the plateau and its slopes and red earths, found on the lower slopes of the plateau below the zone of the acid brown earths (Sibley 1975).

The Baw Baw Plateau consists of a diverse assemblage of vegetation communities, including sub-alpine woodland, in which there exists two variants (shrubby and grassy sub-alpine woodland), wet sub-alpine heathland, damp sub-alpine heathland, dry sub-alpine shrubland, grassy sub-alpine shrubland, dry rocky sub-alpine grassland and montane riparian thicket (Moorrees and Molnar 1991; Cameron 1994). Sub-alpine woodland communities are predominantly restricted to ridges on the plateau while the other communities occur primarily in frost hollows or rocky areas (Fig. 3).

Most of the Plateau is included in the Baw Baw National Park, with the exception of approximately 3.5 km² near Mt Baw Baw which is managed by the Victorian Alpine Resorts Commission.

Data collection and analysis

Audio strip transects (Zimmerman 1994) were used to estimate relative abundance, determine distribution and describe breeding habitats and microhabitats of male *P. frosti.* Previous surveys (Malone 1985a) used the same technique which was found to be very useful for detecting calling males during their restricted breeding season (two to three weeks in late spring; Malone 1985a). Due to the cryptic nature and complex breeding habitat of the species (small cavities within wet sub-alpine heathland), other census techniques were considered less suitable, particularly in a survey designed to cover a large area in a short time.

The technique used involved two searchers walking in opposite directions around the perimeter of a frost hollow (10-50 m from the snow-gum woodland boundary)

Fig. 3. Baw Baw Frog habitat, The Morass, Baw Baw Plateau, Victoria. *(Photo: Gregory J. Hollis).*

and recording the number of calling males. Surveys were carried out diurnally at air temperatures above 5° C. The previous distribution of male choruses was found to be restricted primarily to the slopes of frost hollows rather than their basins, and high levels of calling activity occur diurnally at temperatures above 5° C (Malone 1985a). Along each transect the searchers periodically stopped for one to five minutes to listen for, and count calling frogs. Within any given search area, this method provided a measure of relative abundance of calling males. As many frost hollows as possible were surveyed across the plateau during the period in which frogs were calling. Commencement of calling activity was determined by regularly visiting a number of easily accessible frost hollows (Creek Corner and Village Flat; Fig. 4) early in the breeding season. To monitor variation in calling activity, and determine when calling activity ceased, repeated surveys were conducted at one to two week intervals within sections of two frost hollows (Baragwanath Flat and Currawong Flat) throughout the breeding season. Frost hollows surveyed varied in size from 124.8 ha (Mustering Flat) to 1.2 ha (Access Road 3) and represented approximately 60% of those containing suitable breeding habitat on the Baw Baw Plateau.

Geographic names and the distribution of frost hollows across the plateau were taken from the 1:25000 map of the Baw Baw Plateau (Balkau 1987) and aerial photographs (Latrobe Regional Commission Project 1988). In cases where geographic names of frost hollows were not provided by Balkau (1987), names were assigned on the basis of the nearest geographic feature such as a river or mountain (Fig. 4).

Vegetation community types within alpine and sub-alpine areas in Victoria have previously been based on the vegetation classification by Walsh *et al.* (1984). However, a more recent classification of Victorian Central Highlands vegetation communities by Moorrees and Molnar (1991), and an assessment of the vegetation proposed to be affected by ski trails at Lake Mountain (Cameron 1994), have provided detailed vegetation community descriptions. The present study adopts these new taxonomic community descriptions, although the full range of vegetation community associations on the Baw Baw Plateau is yet to be fully described (J. Davies *pers. comm.*). During surveys of calling males, prominent floristic and structural attributes of all frog localities, including microhabitats, were recorded. A draft 1:25000 map of the Baw Baw Plateau detailing vegetation communities and Baw Baw Frog habitat classes (Roberts 1994) was used as an aid.

A census of deposited egg masses at male calling sites was also conducted. This was expected to provide a relative measure of breeding activity of females within the frost hollows sampled and of the relationship between numbers of calling males recorded and egg masses. Previous searches for egg masses showed they are deposited at, or within the vicinity of, calling sites (B. Malone *pers. comm.*). Whilst undertaking repeated surveys of calling males at Baragwanath Flat and Currawong Flat, accurately located calling sites were marked with flagging tape. A number of calling sites at Access Road 1 and Village Flat (Fig. 4) were also marked. On 16 December (after calling activity had ceased on the plateau) each site was systematically searched by two persons for 15 minutes over an approximate area of 5 x 1 m either side of the marked site (most calling sites were along linear drainage lines) and the number of egg masses counted.

Survey comparison

Surveys conducted in 1983 and 1984 (Malone 1985a) provide the only quantitative data on relative abundance, distribution and habitat of *P. frosti* with which comparisons can be made. Because both survey design and census techniques used in the 1993 survey followed those used by Malone (1985a), it was possible to undertake comparative analyses on three survey data sets (1983, 1984 and the present survey).

The relative abundance, distribution, breeding habitat and duration of calling activity of male frogs are compared. Comparisons of calling male counts between surveys are made from the same set of frost hollows. Most frost hollows surveyed in the present study were also surveyed by Malone (1985a) in either 1983 or 1984, or both. However, portions of some of these areas were not surveyed in this study, but were in the 1983 and 1984 surveys. After inspecting descriptions of Baw Baw Frog breeding habitats presented by Malone (1985a), these portions were considered to

Fig. 4. Distribution, number and locality of male Baw Baw Frog calling sites within frost hollows on the Baw Baw Plateau, October-December 1993. For frost hollows surveyed more than once, the number of calling males (N) refers to the total number of calling males derived from all censuses.

be unsuitable for breeding; they were often dry and rocky with no aquatic habitat (e.g. frost hollows near Whitelaw Ruins; Fig. 4). Field constraints (e.g. logistics and adverse weather conditions) also prevented some surveys from being completed.

The demarcation of some frost hollows presented by Malone (1985a) (Currawong Flat, Baragwanath Flat, Gwinear Flat and Jeep Track) was not provided, and as a result the exact location to which his calling male census statistics belong are not clear. To allow comparison, Malone's separate census statistics for each of these frost hollows have been amalgamated into one statistic for each frost hollow.

Frost hollows with a relatively large area un-surveyed in 1993 (East Tanjil and Chairlift frost hollows) were excluded from analysis. A number surveyed north-west of Mt Whitelaw (Whitelaw 11-13) were also excluded. To avoid the possibility of using re-counts of calling males in frost hollows which had their area surveyed more than once, only one census statistic (the largest) was used in calculations and analyses of relative abundance. Some larger frost hollows that required more than one census on different days to complete had their separate statistics summed in order to derive a single total statistic.

Pearson correlations (Systat, Inc., 1800 Sherman Ave, Evanston, Illinois, 60201-3793) were conducted on measures of relative abundance recorded over the three surveys to assess relationships between frog densities within individual frost hollows. Comparisons were also made of the altitudinal distribution of calling sites and the frequency of occurrence of calling males recorded within different vegetation community types and microhabitats.

A preliminary inspection of spring and summer rainfall totals over the three surveys (1983 to 1994) was undertaken to see if they provided any insight into differences observed between surveys. Spring (September - November) and summer (December - February) monthly rainfall totals were summed and a mean monthly total was derived for each season in each year. These records were collected from Erica (Department of Conservation and Natural Resources), a location close to the Baw Baw Plateau, in the absence of a weather station on the plateau. Spring and summer rainfall records were used because this is the period over which the Baw Baw Frog is involved in calling activity, oviposition, egg development and larval development through to metamorphosis (Malone 1985a), and are considered the most vulnerable phases of the anuran life cycle (Williamson and Bull 1994).

Results of 1993 Survey

Calling activity, relative abundance and distribution

Figure 4 shows the distribution, number and localities of calling male Baw Baw Frogs recorded in different frost hollows surveyed on the Baw Baw Plateau. Initial surveys conducted at Creek Corner and Village Flat frost hollows between 28 October and 3 November 1993 failed to detect any calling activity. An unseasonable snowfall of 50 cm which covered the Baw Baw Plateau from 3-11 November limited surveys but this may not have affected the census because only low levels of calling activity are exhibited by the Baw Baw Frog at temperatures below 5° C (Malone 1985a). Calling activity was first detected on 15 November 1993, from one frog at Access Road 1 and two at Village Flat, and appeared to cease on approximately 13 December when no calls were recorded from Baragwanath Flat and Currawong Flat. These two frost hollows were surveyed four times throughout the breeding season and recorded the following number of calling males respectively: (4, 0 [17 Nov]; 6, 2 [29 Nov]; 3, 0 [6 Dec]; and 0, 0 [13 Dec]). Opportunistic visits to sections of a number of frost hollows between 16-21 December, including Village Flat, Pudding Basin, Macallister Plain, Baragwanath Flat, Currawong Flat, East Tanjil, The Morass and Jeep Track 3, failed to detect any calling males. Calling activity appeared to last for approximately four weeks in 1993.

Table 1 summarises the census statistics for each frost hollow surveyed. Forty-three frost hollows were surveyed during the 1993 breeding season with calling males being recorded in 19 of these. Including all census statistics (i.e. re-counts from frost hollows surveyed more than once), a total of 99 calling males was recorded from all frost hollows surveyed on the plateau. Numbers ranged from 0-30 in any one single survey. Including only the largest census result from frost hollows surveyed more than once, the total number of calling males recorded

Table 1. Relative abundance of calling male Baw Baw Frogs recorded within different frost hollows on the Baw Baw Plateau during surveys conducted in 1993, 1983 and 1984.
* denotes the largest census statistic obtained from frost hollows surveyed more than once in 1993.
— denotes frost hollows that were not surveyed. **NA** denotes un-available information. **Note:** Currawong Flat 2 refers to a small portion of Currawong Flat surveyed in 1993, 1983 and 1984; the census statistic for 1993 and 1983 are not included in their respective totals as they already contribute to the census statistic for Currawong Flat.

Frost Hollow	Approx. Area (ha)	Approx. Area Surveyed (ha)	Total 1993 Survey in pers. hrs.	Total No. Calling Males in 1993, all surveys	No. Calling Males in 1993	No. Calling Males in 1983	No. Calling Males in 1984
Access Road 1	1.9	5.7	1.5	3	2*	43	21
Access Road 2	1.7	3.4	0.7	0	0*	30	26
Access Road 3	1.2	2.4	0.7	0	0*	0	0
Chairlift	10.8	1	0.7	0	0*	6	8
Village Flat	26.8	26.8	6.5	4	3*	183	149
Neulyne Plain	2.3	2.3	1.2	2	2	24	—
La Trobe Plain	7.5	7.5	3.2	3	3	206	—
Macallister Plain	5.3	5.3	2.7	5	5	82	—
Pudding Basin	5.5	11.5	6.4	2	2*	101	—
Moondarra Flat	8.7	11.6	4.5	0	0*	225	—
Baragwanath Flat	23.7	83.1	21.2	22	11*	167	245
Currawong Flat	66.2	132.2	26.2	8	8*	536	—
Currawong Flat 2	NA	NA	NA	2	2*	174	231
Creek Corner	1.7	3.9	3.5	0	0*	52	49
Tanjil Plain	4	4	3	9	9	120	—
East Tanjil	5.2	2.1	1	1	1	71	—
McMillian's Flat	1.7	3.4	0.8	0	0*	64	—
The Morass	95.4	89.4	14.3	30	30	667	—
Jeep Track 1	15.4	15.4	1.9	0	0	0	0
Jeep Track 2	8.1	3.4	0.5	0	0	6	0
Jeep Track 3	2.6	4.5	0.7	0	0*	3	0
Jeep Track 4	13	13	1.3	0	0	0	0
Freeman's Flat	28.7	28.7	4.8	0	0	41	104
Wombat Flat	8.7	8.7	2.8	1	1	—	18
Tyers River 1	9.8	9.8	2.3	0	0	14	9
Tyers River 2	1.6	1.6	1.2	0	0	7	3
Mustering Flat	124.8	124.8	8	0	0	57	0
Gwinear Flat	45.6	45.6	5.7	0	0	93	2
Cascade Creek	14.4	14.4	2.3	0	0	—	0
Whitelaw 1	3.9	3.9	1.5	2	2	0	—
Whitelaw 2	10.4	10.4	4.2	2	2	67	—
Whitelaw 3	3.7	3.7	1.3	0	0	—	28
Whitelaw 4	3.1	3.1	1.9	0	0	39	—
Whitelaw Ruins	27.5	27.5	6.6	1	1	164	—
Whitelaw 5	1.9	1.9	0.7	1	1	53	—
Whitelaw 6	3.6	3.6	1.1	0	0	49	—
Whitelaw 7	7.3	7.3	1.5	0	0	96	—
Whitelaw 8	5	5	1.8	0	0	30	—
Whitelaw Creek	34.1	31.2	9.2	1	1	368	—
Whitelaw 9	6	6	1.4	0	0	90	—
Whitelaw 10	4.4	4.4	1.6	1	1	17	—
Whitelaw 11	7.8	1.3	0.7	0	0	NA	NA
Whitelaw 12	1.6	1.6	0.7	1	1	NA	NA
Whitelaw 13	1.7	1.7	0.7	0	0	NA	NA
TOTAL	**664.3**	**778.1**	**164.5**	**99**	**86**	**3771**	**893**

was 86. The largest number of calling males recorded over four repeated surveys of Baragwanath Flat and Currawong Flat was six and two respectively.

Calling males were distributed over the western, northern and central regions of the Baw Baw Plateau, but were not heard on the eastern side (Fig. 4). No surveys were conducted in the south-east region of the plateau because of time constraints brought about by adverse weather conditions during the initial stages of the survey and by what appeared to be a short breeding season. All calling males were located within or at the periphery of frost hollows along intermittent water courses or seepages. Their distribution was restricted primarily to dendritic or elongate frost hollows (e.g. La Trobe Plain), or to elongate portions of broader frost hollows (e.g. The Morass; Fig. 4). Calling males in most cases did not form aggregations, typically being recorded as solitary individuals

Habitat preferences

Calling males were recorded within two vegetation communities and three vegetation community ecotones. These included: wet sub-alpine heathland (39 frogs; 39.4%) and montane riparian thicket (21; 21.2%), wet sub-alpine heathland dry sub alpine shrubland ecotone (8; 8.1%), wet sub-alpine heathland - montane riparian thicket ecotone (5; 5.0%) and wet sub-alpine heathland - sub alpine woodland ecotone (26; 26.3%)

The positions of 87 males (from the total of 99) were located accurately enough to describe their microhabitat (Table 2). Fifty nine frogs were located in small cavities along seepage lines created by the roots of shrubs (typically *Richea continentis*, *Epacris paludosa*, *Baeckea utilis* var. *latifolia*, *Orites lancifolia*, *Callistemon pityoides*, *Leptospermum grandifolium* and *Nothofagus cunninghamii*) associated with smaller ground-cover species (*Sphagnum cristatum*, *Polytrichum alpinum/commune*, *Wittsteinia vacciniacea*, *Astelia alpina* and *Carex gaudichaudiana*) and peat soil. Fourteen frogs were recorded beneath or at the base of large granite boulders (2 m²) with a soil or peat substrate only. Of the remaining frogs, six were found beneath logs in association with peat soil, *C. gaudichaudiana*, *W. vacciniacea* or *P. alpinum/commune* and seven in cavities beneath *W. vacciniacea* or *A. alpina* in association with peat soil

Table 2. Number of calling male Baw Baw Frogs (*Philoria frosti*) recorded in different breeding microhabitats and associated vegetation types during surveys conducted on the Baw Baw Plateau between 28 October and 13 December 1993. Key to Breeding Microhabitats: **1** - Peat cavities under roots of shrubs; **2** - Peat cavities under logs/rocks; **3** - Cavities beneath *W. vacciniacea/A. alpina*.

Vegetation Communities/Ecotones	Breeding Microhabitats		
	1	2	3
Wet Sub-alpine Heathland	18	17	
Montane Riparian Thicket	11	3	7
Wet Sub-alpine Heathland / Montane Riparian Thicket ecotone	2		
Wet Sub alpine Heathland /Dry Sub alpine Shrubland ecotone	6		–
Wet Sub alpine Heathland /Sub-alpine Woodland ecotone	22	1	

or *P. alpinum/commune*. Only one male was located beneath small moss-covered rocks (<20 cm²) and logs within a creek.

Egg masses

From 14 calling sites searched, only two egg masses were located, for a total search effort of seven person-hours over 70 square metres of breeding habitat. Both were located at Currawong Flat. The first of these was found in a soil cavity (15 cm depth) along a seepage line at the base of a large granite boulder (3-4 m²) in wet sub-alpine heathland/sub-alpine woodland ecotone. Plant species occurring outside this soil cavity included *C. gaudichaudiana* and *S. cristatum*. The egg mass was fertile and contained approximately 20-30 live unpigmented larvae at Gosner Stage 22 (Gosner 1960). The other egg mass was found in sub-alpine wet heathland along a seepage line within a cavity created by roots of the shrub *R. continentis* in association with peat soil, *A. alpina* and *S. cristatum*. This egg mass appeared to have desiccated as only three partially decomposed egg capsules were found. The few egg masses recovered from searches may reflect minimal oviposition by female Baw Baw Frogs. However, due to the microhabitat complexity of some search sites (e.g. under large granite boulders), a thorough search was not possible and could only be attained if destructive searches were undertaken.

Comparison of 1983, 1984 and 1993 Survey Results

Calling activity, relative abundance and distribution

The calling activity period of the 1993 survey (15 November - 13 December) was considerably shorter than that observed by Malone (1985a). He heard males calling as early as the third week of October and continuing as late as the 24 December in 1983 and 1984 (approximately 8 weeks). Calling activity was greatest between 17-29 November 1993 which is similar to that reported by Malone who noted a peak in calling activity between 11-29 November (1983/84).

Over the 1983 and 1984 surveys, Malone (1985a) recorded calling males in 73% (64 of 88) of frost hollows surveyed, compared to 46% (22 of 48) in 1993 (using Malone's frost hollow units). In a subset of 35 frost hollows surveyed in both 1983 and 1993, Malone (1985a) recorded 3694 males compared with 83 in this survey. In a subset of 19 frost hollows surveyed in both 1984 and 1993, Malone (1985a) recorded 885 males compared with 19 in this survey. This survey only recorded 2.2% and 2.1% of the number of calling males recorded by Malone in 1983 and 1984 respectively, whereas, in frost hollows surveyed twice in consecutive breeding seasons by Malone, in 1984 he recorded 97% of the number counted in 1983. Together with the 1993 survey results, Table 1 shows the number of calling males recorded in each frost hollow in the 1983 and 1984 surveys. Measures of relative abundance (i.e. frog counts) within the same frost hollows for each survey were highly correlated (1983/84: $r^2 = 0.87$, n = 16, P<0.001; 1983/93: $r^2 = 0.75$, n = 35, P<0.001; 1984/93: $r^2 = 0.71$, n = 19, P<0.005), indicating that the differences in frog densities between frost hollows were proportionally the same across all surveys.

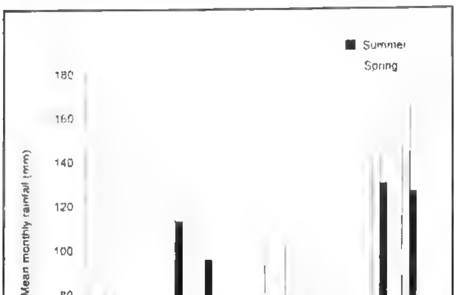

Fig. 5. Mean monthly spring and summer rainfall at Erica (DCNR), Victoria from 1983-1994.

The distribution of calling males recorded in 1993 was similar to that observed by Malone in 1984 when males were restricted primarily to the central, western and north-western regions of the Baw Baw Plateau (Fig. 4). By contrast, during the 1983 survey Malone recorded calling males in the eastern region of the plateau. No surveys were conducted in the south-eastern region of the plateau in 1993 to compare with Malone's, although he found the Baw Baw Frog to be conspicuously absent from unforested areas in the south-east in both 1983 and 1984.

Comparison of altitudes from 1993, 1983 and 1984 calling sites showed that, in the same 15 frost hollows, there was no significant difference in the distribution of calling sites (1983: mean ± SE = 1442.9 ± 6.1 m, n = 123, range = 370 m; 1984: 1441.7 ± 8.3 m, n = 86, range = 370 m; 1993: 1435.0 ± 18.5 m, n = 17, range = 270 m). In 1993, the range (lowest to highest altitude) of calling sites was less, and the mean altitude lower, than in the 1983 and 1984 surveys. A greater proportion of calling sites (31.4%) in 1993 were located at lower altitude (1150-1350 m) when compared with the 1983 and 1984 surveys, where fewer sites (20.6%) occurred.

Habitat use and breeding microhabitats

Malone (1985a), by using vegetation units described by Walsh *et al.* (1984), recorded breeding males (calling and non-calling males) in the following four habitat classes in 1983 and 1984 surveys: wet alpine heath - 1148 frogs (22.5%); wet alpine heath/bog ecotone - 3834 frogs (75.0%); bog - 82 frogs (1.6%); grassland (modified areas in the Baw Baw Alpine Resort) - 45 frogs (0.9%). He also recorded 102 frogs (2.4%) (calling males only) in habitats with a sparse under storey of *N. cunninghamii* and *L. grandifolium* but presented this as a separate statistic. To allow comparison with this survey, a number of the habitat classes adopted by Malone (1985a) had to be correlated with the vegetation classification adopted in this study; wet alpine heath, wet alpine heath/bog ecotone and bogs fit into the vegetation community 'wet sub-alpine heathland' while habitats with a sparse understorey of *N. cunninghamii* and *L. grandifolium* fall into the vegetation community 'montane riparian thicket'.

In 1993, 39.4% were recorded in wet sub-alpine heathland compared with 99.1% found by Malone (1985a). In ecotonal habitats, 39.4% were recorded at the periphery of wet sub-alpine heathland adjacent to either sub-alpine woodland, montane riparian thicket or dry sub-alpine shrubland. Malone did not record aggregations of calling males in these habitats (B. Malone *pers. comm.*). In montane riparian thicket and bog habitat 21.2% and 1.0% were recorded respectively, compared with 2.4% and 1.6% by Malone. Frogs recorded in bogs are also included in the 'wet sub-alpine heathland' percentages above. In the present survey no frogs were recorded within modified areas in the Baw Baw Alpine Resort compared with 0.9% found by Malone (1985a).

The microhabitats in which many calling males were recorded in 1993 appear different from microhabitats in which Malone (1985a) reported oviposition sites in 1983 and 1984. He recorded egg masses in natural cavities in vegetation (including *Sphagnum* spp., *A. alpina, Empodisma minus, E. paludosa, R. continentis* and *Carex* spp.) which acted as catchments for water travelling down slope, and under building materials, rocks and logs which occurred mostly in modified areas within the Mt Baw Baw Alpine Resort. In 1993, calling males and egg masses were also located in natural cavities which retained water, but none of these were located in modified microhabitats within the Mt Baw Baw Alpine Resort, and not all cavities were in vegetation. For example, 14 males were located in soil or peat crevices beneath large granite boulders. Those recorded in cavities created by vegetation were associated with most of the species reported by Malone (1985a), with the exceptions being attributable to proportionally greater number of males being located in association with species that occur in montane riparian thicket (*N. cunninghamii, L. grandifolium* and *W. vacciniacea*).

Rainfall

Figure 5 shows mean monthly spring and summer rainfall totals spanning the 1983, 1984 and 1993 surveys. The mean (± SE) monthly spring and summer rainfall total over all years examined was 117.2 ± 7.2 and 82.2 ± 8.1 mm respectively. Rainfall received during both 1983 and 1984 surveys was below the average for the decade, while rainfall received during the 1983 survey was greater than that received in 1984. In spring and summer of 1993, rainfall was considerably higher than in both surveys conducted by Malone (1985a), and the average for the decade. In several years preceding 1993 (1987/88 to 1991/92), spring and summer rainfall was relatively low, particularly summer rainfall, which was below the average for all of these years.

'Note *in press*'

Baw Baw Frog surveys conducted recently in November and December 1994 confirm the decline in calling males recorded in 1993. The number of calling males recorded in 1994 was 15% lower than that recorded in the 1993 survey and approximately 2% of numbers recorded a decade ago. As in the 1993 survey, the distribution of calling males was restricted to the western, northern and central regions of the Baw Baw Plateau. Many of the localities at which calling males were recorded in 1994 were identical to those recorded in 1993, with preferred breeding habitats restricted to topo-graphically protected gullies with wet sub-alpine heath and montane riparian thicket vegetation.

Discussion

Survey results

The relative abundance of calling male Baw Baw Frogs across all frost hollows surveyed in 1993 was approximately 2% of the numbers recorded by Malone (1985a) a decade ago, indicating a size reduction in the male frog population by several orders of magnitude. Malone concluded that actual numbers of males were probably two to three times the number heard because of the presence of silent males in the vicinity of calling males and the frequent occurrence of more than one male at a calling site. From these observations he estimated that the adult male Baw Baw Frog population was 10,000 - 15,000. Using the same procedure, the adult male population would be in the vicinity of 200 - 300 individuals in 1993. Data on abundance of the Baw Baw Frog prior to 1983 are only qualitative (Atlas of Victorian Wildlife, Dept of Conservation and Natural Resources, Heidelberg) or anecdotal. Frogs appear to have been relatively easy to locate during the 1950's, 1960's and 1970's (M. Littlejohn *unpubl. data*, J. Coventry *pers. comm.*), but from 1989 to 1992 only low numbers of calling males have been detected (W. Osborne, J. Morey, P. Johnson *pers. comm.*) when compared with numbers recorded in 1983 and 1984. The results from the present survey are in accordance with these later observations.

Calling males tended to be confined to topo-graphically protected sites within shaded and moist gullies. These appear refugial when compared with former known breeding habitats where frogs were distributed over a wider area in wet sub-alpine heathland (see Malone 1985a). The lower mean altitude and range over which calling sites were recorded in 1993 can be attributed to the proportionally higher number of males recorded in montane riparian thicket and ecotonal habitats at the periphery of wet sub-alpine heathland. Montane riparian thicket typically occurs at lower altitudes than wet sub-alpine heathland, often arising at the drainage outlets of sub-alpine heathlands, and descending to intergrade with cool temperate rainforest or thickets at lower altitude (Moorrees and Molnar 1991).

Possible reasons for an apparent decline

Two possible scenarios may explain these results:

1) The first possibility is that **the Baw Baw Frog population has declined** and the species could be threatened with extinction. In the light of many recent reports of rapid population declines and possible extinctions in amphibians, concern for the stability and conservation status of the Baw Baw Frog population is justified. Although some amphibian declines have been attributed to anthropogenic disturbances such as habitat destruction and chemical pollution (Blaustein and Wake 1990; Vitt *et al.* 1990; Wyman 1990; Gillespie and Hollis *in press*), other declines are not readily explained. In these cases other hypotheses have been suggested, including acid precipitation, increased ultraviolet radiation, introduced exotic species, pathogens and climate change (Blaustein and Wake 1990; Blaustein *et al.* 1994; Osborne 1990; Phillips 1990; Pechmann *et al.* 1991; Trenerry *et al.* 1994; Wyman 1990).

Obvious anthropogenic disturbances on the Baw Baw Plateau appear limited when compared with amphibian habitats in other places. Modification of frog habitat through the construction of trails and areas for skiing and bushwalking is the main disturbance. However, this appears to be an unlikely explanation for the low number of males recorded because the decline across the plateau is relatively uniform and the modified habitats are relatively localised, although levels of embryonic and larval mortality of the Baw Baw Frog have previously been shown to be higher in these modified habitats because of increased desiccation, resulting in reduced recruitment (Malone 1985b). If the species has declined in these modified areas, it is not possible at this stage to distinguish between this decline and what appears to be a decline across the entire plateau. To a lesser extent, trampling and browsing by introduced species such as cattle and deer have also impacted adversely on habitat (G. Hollis *pers. obs.*). Less obvious disturbances such as the effects of introduced predators (foxes, dogs and cats perhaps with pathogens) and pollution from local industrial activity in the form of atmospheric deposition could also affect the Baw Baw Frog in an adverse way.

2) The results may also reflect **normal population fluctuations in response to environmental variation** (see reviews by Blaustein 1994; Pechmann and Wilbur 1994). The reduced breeding activity observed in this survey may have occurred as a result of poor breeding conditions. Alternatively, the low number of calling males may be indicative of an actual male population size, but is typical of normal population fluctuations. Some amphibian studies have shown that variations in climatic factors such as temperature and rainfall are unrelated to observed declines (e.g. Richards *et al.* 1993) while others have linked such events to drought or low precipitation (Osborne 1990; Pechmann *et al.* 1991; Crump *et al.* 1992), severe frosts (Heyer *et al.* 1988), or the synergistic effects of climatic and other environmental variables (Pounds and Crump 1994).

Low spring and summer rainfall from the years 1987/88 to 1991/92 (Fig. 5) could be responsible for the small number of calling males recorded in 1993. Recruitment of frogs over this period may have been low due to increased desiccation of embryos and larvae resulting from low summer rainfall, and these frogs could now be the 1993 adult cohort. It cannot be determined whether the higher spring rainfall received in this survey was responsible for the reduced calling activity recorded, when compared with the 1983 and 1984 surveys when lower spring rainfall was received and greater calling activity was recorded. The lower spring rainfall received during the 1984 survey, when compared to 1983, could also explain why Malone (1985a) observed a contraction in range of breeding by the Baw Baw Frog from the eastern side of the plateau, while frost hollows on the western side recorded similar numbers of calling males in both 1983 and 1984. The eastern side of the Baw Baw Plateau is primarily drier and rockier than the central and western sides (Roberts 1994) and may become unsuitable for breeding in dry periods. However, in this survey a contraction in breeding range from the eastern side of the plateau, similar to that recorded in 1984, was observed during a period of high spring rainfall. A more detailed inspection of longer-term climatic data over several decades is required before any further conclusions can be made, particularly considering the absence in knowledge of the longevity of the Baw Baw Frog and the impact that rainfall and other climatic factors has on its breeding biology.

Although the fundamental characteristics of the ecology and biology of the Baw Baw Frog have been discussed and documented (Martin 1967; Watson and Martin 1973; Littlejohn 1963; Malone 1985a; Malone 1985b), little is known about the demography and population dynamics of this species. According to Blaustein *et al.* (1994), without long-term data detailing demography and dynamics of amphibian populations it is very difficult, if not impossible, to unambiguously state whether or not they are suffering unusual declines. Therefore, interpreting the results of this survey as indicating a population change outside the bounds of 'normal' fluctuations could be considered premature, although the 1994 survey results obtained recently also confirms this apparent decline.

Long-term monitoring and research into the population dynamics and demography of the Baw Baw Frog is required to assess population stability and determine whether or not it is suffering an unusual decline. Monitoring of the population will be undertaken in the 1994 and 1995 breeding seasons by the Department of Conservation and Natural Resources. Planned research includes: (1) age determination (using skeletal chronology) to assess longevity; (2) mark-recapture studies and radio tracking, to provide information on population size, dispersal and utilisation of other habitats; and (3) an assessment of the impact of climate on breeding activity. Guidelines outlining current conservation and management objectives for the Baw Baw Frog are contained in CNR (1993b).

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Biosystematics of Australian Mygalomorph Spiders: Two New Species of *Arbanitis* from Victoria (Mygalomorphae: Idiopidae)

Barbara York Main[1]

Abstract

The genus *Arbanitis* is newly recorded in Victoria from Bairnsdale, Mt Buffalo and Glenaladale National Park and two new species are described. The occurrence of the genus in Victoria indicates a continuous distribution, albeit restricted to suitable habitats, from North Queensland to Tasmania.

Introduction

This paper is the eleventh in which I deal with the systematics of Australian Ctenizidae and Idiopidae as defined by Raven (1985)(see Main 1983, 1985 a, b for bibliography of earlier papers and Main, 1993, for re-establishment of two genera).

Arbanitis Koch is one of the most widespread genera of trapdoor spiders in Australia (Main 1985a). Raven (1985) transferred *Arbanitis* from the Ctenizidae to his newly erected family Idiopidae. *Arbanitis* as currently defined (Main 1985b) has been recorded from Tasmania, north-eastern New South Wales, south-eastern and mid Queensland, south-western Western Australia and one species from the Lofty Ranges in South Australia (Davies 1976; Gray 1976; Hickman 1967; Koch 1873, 1874; Main 1964, 1981, 1985b; Rainbow and Pulleine, 1918). However, from personal collecting and examination of museum collections it is apparent that the genus is much more widely distributed in eastern Australia, from Cape York to Tasmania, than is indicated either in biological survey reports or from descriptions of nominal species. Similarly in Western Australia, although only species from the south-west have been described, personal observations and collecting as well as the specimens in the Western Australian Museum collections, show that *Arbanitis* extends well into the semi-arid region.

These widely scattered records then raise doubts about the authenticity of the locality of the South Australian species *A. zorodes* (Rainbow and Pulleine) because no specimens additional to that of the type (Rainbow and Pulleine 1918) have been recorded from South Australia. Main's reference to the occurrence of *Arbanitis* in Central Australia (Main 1981) was in error as the species on which this statement was based was later transferred to *Blakistonia* (Main 1985a, b).

This paper records, for the first time, the occurrence of *Arbanitis* in Victoria, and describes two new species. The type specimens are housed in the collection of the Museum of Victoria.

I have also collected immature specimens from Glenaladale National Park.

Methods

The format for species descriptions follows that of earlier papers (see Main 1985b). Measurements are in millimetres throughout descriptions.

Abbreviations. In reference to eyes: ALE, AME, PLE and PME, anterior lateral and anterior median, posterior lateral and posterior median respectively. In reference to position of scopula, trichobothria and tooth rows of tarsal claws: P, prolateral; R, retrolateral; p, prolateral; r, retrolateral; v, ventral; d, dorsal; pv, pro-ventral; rv, retro-ventral; pd, pro-dorsal. MV, Museum of Victoria; BYM, Barbara York Main collection housed in the Zoology Department, University of Western Australia.

Systematics

Arbanitis victoriensis sp. nov.

(Figs. 1 - 10 and Table 1)

HOLOTYPE: Female, Buffalo River Dam, 8 September 1965 (MV K-3001).

Colour (in alcohol) tan brown, chelicerae reddish, abdomen dark brown, dorsally with conspicuous, but pale, broken bands. *Carapace* glabrous; length 8.5, width 7.5. Deep cervical 'pits'. *Fovea* deeply procurved, slightly 'efoveate' i.e. with backwardly directed swelling over the depression. Caput with high hump between eyes and fovea but with a depression immediately behind eyes;

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Table 1. Leg measurements of *Arbanitis victoriensis* sp. n. female holotype. [The leg formula is the length of leg divided by length of carapace (from anterior mid-margin to posterior mid-margin). The tibial index is the width of patella x 100, divided by length of patella plus tibia (Petrunkevitch 1942)].

Leg formula:		4	1	2	3	
		2.07	1.67	1.58	1.47	
	F	P	Ti	M	Ta	Total
I	4.5	3.2	2.8	2.0	1.7	14.2
II	4.4	3.1	2.4	1.9	1.7	13.5
III	3.5	3.2	2.6	2.3	1.9	12.5
IV	5.0	3.6	3.4	3.5	2.1	17.6
Palp	4.2	2.7	2.3	—	2.7	11.9

Width of patella I at knee = 1.3. Tibial index = 21.6.
Width of patella IV at knee = 1.6. Tibial index = 22.2.

clypeus short. A line of a few short, fine hairs between eyes and fovea; a group of about eight pre-ocular bristles; a clump of at least 10 bristles between posterior eyes. Eye group compact, anterior width 1.7 mm, posterior width 1.9 mm, length 0.9 mm; anterior row almost straight. Diameters of eyes: ALE 0.4 mm, AME 0.15, PLE 0.3, PME 0.15.

Chelicerae with longitudinal band of stout bristles; rastellum of long pointed teeth on apical angle, no process. Teeth of groove (left) p 7, r 9, 4 proximal intermediate; (right) p 7 (plus 2 tiny regen erated teeth on site of second distal tooth) r 8, intermediate 7; prolateral ventral keel on fang. *Sternum* with scattered short and long bristles, length 4.7, width 4.5. Posterior sigilla large, oval, about 0.8 from margin and about 1.8 apart. *Labium* length 1.0, with 2 anterior pointed cuspules. *Maxillae* with about 22 cuspules on inner anterior angle, some reduced bristles but no spinules.

Legs. Scopula, palp tarsus P complete, R incomplete; I, tarsus P, R dense, metatarsus P dense, R apical only. II, tarsus and metatarsus dense P only. *Trichobothria.* Palp tarsus about 12, tibia 6 or 7 in p and r rows. I, tarsus about 12, metatarsus about 8 in irregular row, tibia 6 in p and r rows. II, tarsus 14, metatarsus 10, tibia p 6, r 5. III, tarsus about 12, metatarsus about 8, tibia p 6, r 5. IV, tarsus about 10, metatarsus 7, tibia p 6, r 6. *Tarsal claws* teeth, (right), palp with 2 teeth. Paired claws on legs: I, P 3, R 2 (?). II, (left - right broken) P 2, R 2. III, P 1, R 1. IV, P 2, R 2 (?). *Spines.* Prolateral/ventral edge of femurs of palp and I (and less so on II) with dense line of long, strong bristles. Palp, tarsus pv 4, rv 6, tibia pv 9 (some broken), rv 8. I, tarsus v 4, metatarsus pv 3, rv 7, tibia pv 5, rv 4. II, tarsus v 3, metatarsus pv 3, rv 3, tibia pv 1, rv 1 + 2 tapering bristles. III, tarsus v 4, metatarsus v 3 apical, d 2 apical, pd 2, patella pd 3 in a line. IV, tarsus v 8, metatarsus 4.

Abdomen. Sparsely hairy and with few median dorsal bristles. Internal genitalia, pair of vesicles each with a broad based long stem, narrowing below globose crown; 'tubercles' covering whole of crown and stem (Fig. 10).

Diagnosis

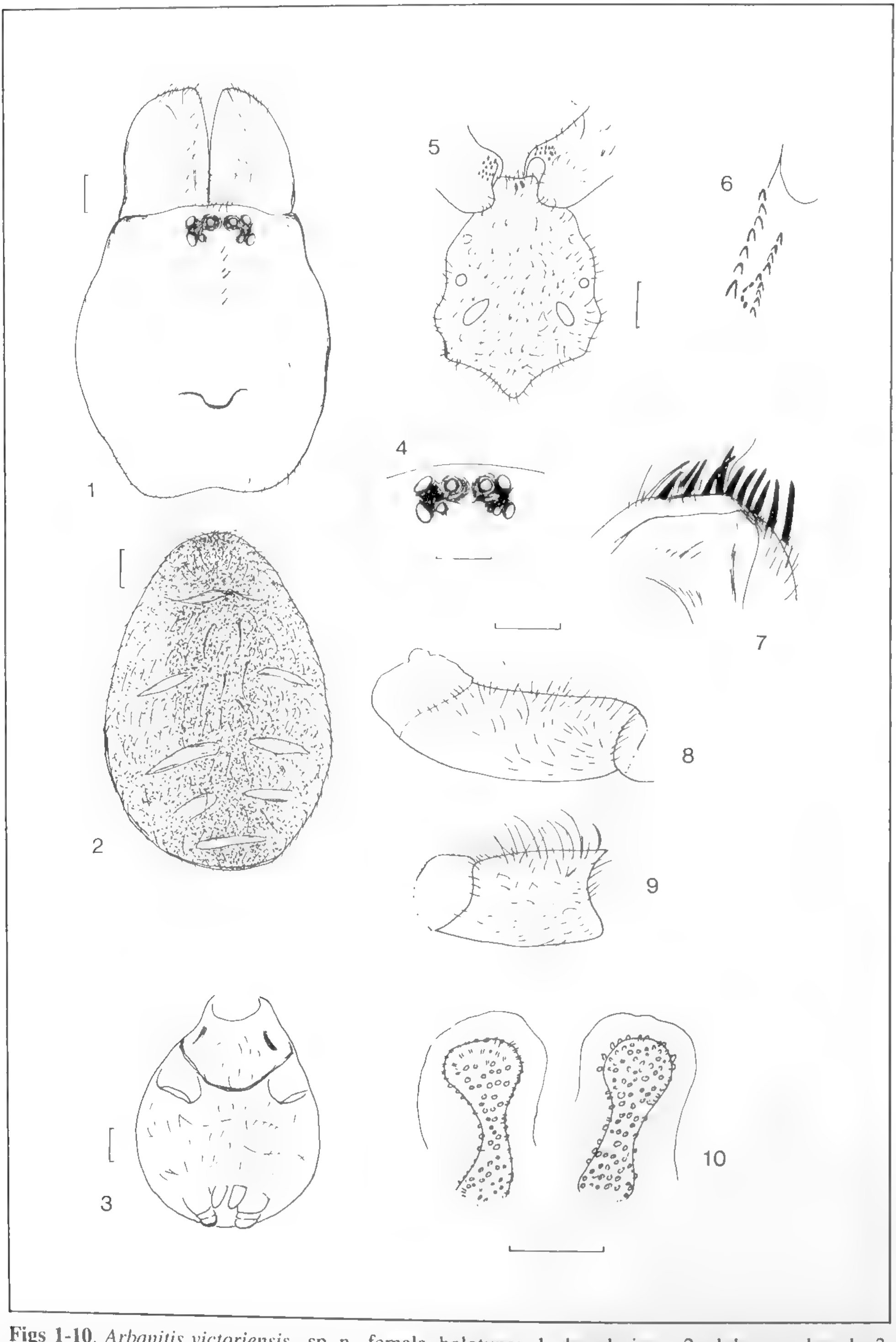
Labium with cuspules; abdomen with sparse hairs and dorsal bars. Legs slightly stouter and less spinose than *A. bairnsdale*, paired tarsal claws with one to three teeth. Internal genitalia with globose vesicles and broadly based, flanged stems.

***Arbanitis bairnsdale* sp. nov.**

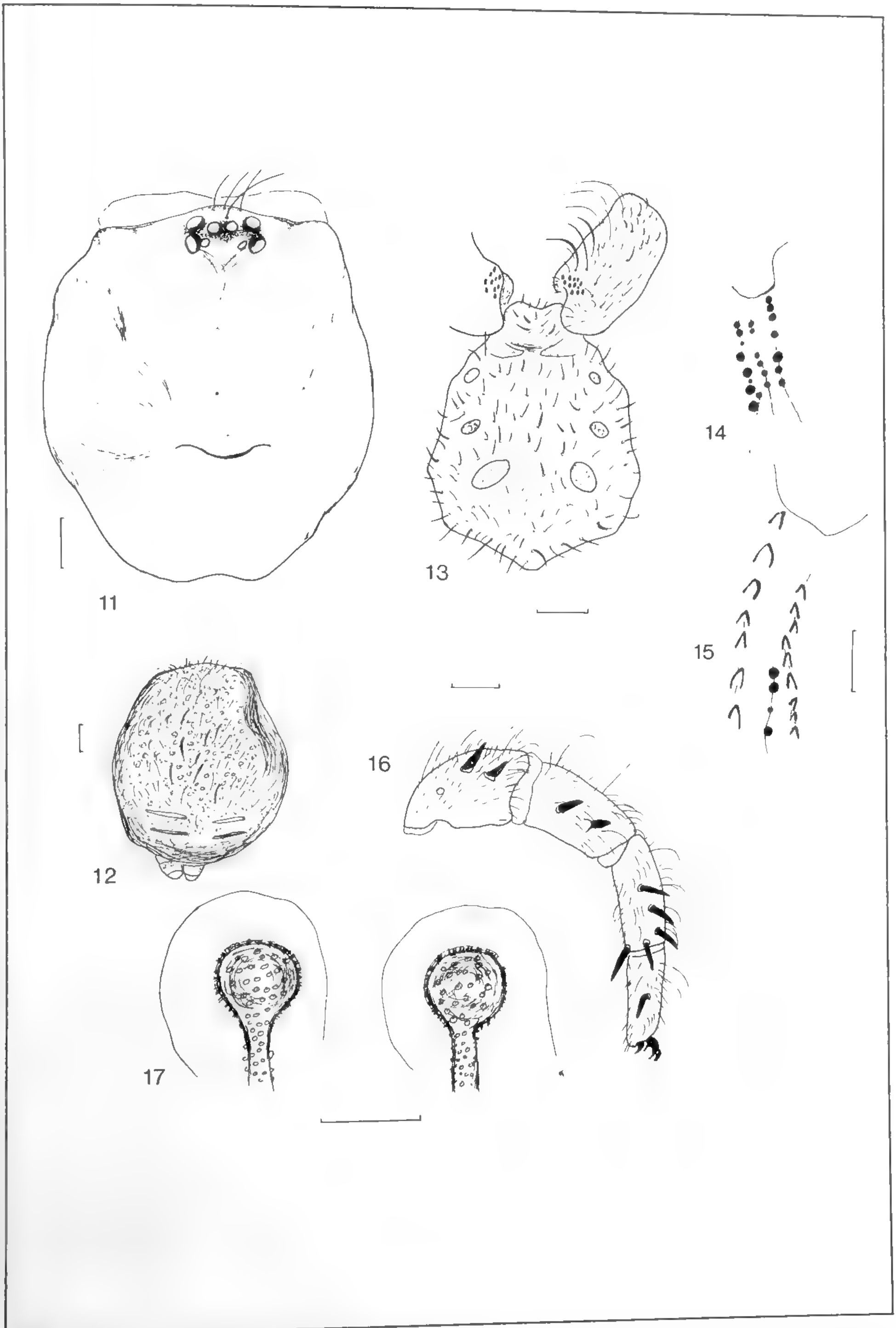
(Figs. 11 - 17 and Table 2)

HOLOTYPE: Female, Bairnsdale, 13 May 1964 (MV K-3002).

Colour tan brown, abdomen dark brown with faint, narrow broken tansverse bands; chelicerae and sternal area reddish brown. *Carapace* glabrous, caput arched, depressed behind eyes, humped in front of fovea.



Figs 1-10. *Arbanitis victoriensis* sp. n., female, holotype; 1, dorsal view; 2, abdomen, dorsal; 3, abdomen, ventral; 4, eyes; 5, sternal area; 6, left chelicera, teeth on groove margins; 7, rastellum, right chelicera; 8, 9, femurs of legs I, II, ventral; 10, internal genitalia, dorsal view. Scale: 1 - 3, 5, 8 , 9 = 1.0 mm; 4 , 10 = 0.5 mm; 6, 7, not to scale.



Figs 11-17. *Arbanitis bairnsdale* sp n. female holotype; 11, carapace; 12, abdomen; 13, maxillae and sternum; 14, 15, right and left chelicerae, groove teeth; 16, prolateral view left leg III, patella, tibia, metatarsus and tarsus; 17, internal genitalia. Scale: 11 - 13 , 15, 16 = 1.0 mm; 17, 0.5 mm; 14, not to scale.

Table 2. Leg measurements of *Arbanitis bairnsdale* sp. n. female holotype. [Method as in Table 1].

Leg formula:		4	1	3 ?	2 ?	
		2.4	1.93	1.84	1.73	
	F	P	Ti	M	T	Total
I	4.5	3.1	2.8	2.0	1.5	13.9
II	3.8	2.7	2.5	2.1	1.4	12.5 ?
III	3.7	2.9	2.5	2.5	1.7	13.3 ?
IV	4.5	3.4	3.8	3.5	2.1	17.3
Palp	3.9	2.5	2.5	–	2.6	11.5

Width of patella I at knee = 1.2. Tibial index = 20.03.
Width of patella IV at knee = 1.4. Tibial index = 19.4.

Fovea procurved (not projecting). Carapace length 7.2, width 6.7. *Eyes*, anterior width 1.5, posterior width 1.5, length 0.7. Clypeus a low mound, with slight anterior peak. Diameters of eyes: ALE 0.4, AME 0.2, PLE 0.2, PME 0.15. *Chelicerae*. Rastellum of stout teeth, decreasing in size dorsally. Teeth on cheliceral fang groove: (Right/Left) 7P, 6 + 3R, 6M / 7P, 9R, 4M; on right chelicera median row in long line, on left chelicera form a stout basal group (Figs. 14, 15). *Sternum* length 4.0, width 4.0; posterior sigilla large, oval. Labium length 1.0, no cuspules or spinules. *Maxillae*, 45 to 50 cuspules on inner anterior angle.

Legs. Scopula: very sparse on palp tarsus, prolateral face only; I, thin on prolateral face tarsus and metatarsus, a few hairs only on retrolateral face; II, thin scopula on prolateral face of tarsus, a few apical hairs on prolateral face of metatarsus. *Trichobothria*. Palp, tarsus with about 11 including some rod-like and slightly clavate, tibia p 8, r 6. I, tarsus with 13 or 14 (non clavate), metatarsus 14 in irregular row. *Tarsal claws*. Palp, claw with two teeth. Paired claws of legs all with a single large tooth, fourth retro-claw with additional small tooth. *Spines*. Palp, tarsus p 7, r 7, tibia p 7, r 6, patella pv 2 apical. I, tarsus, v 7 in group, metatarsus pv 5, rv 6, tibia pv 6, rv 4. II, tarsus v 5, metatarsus pv 5, rv 5, tibia pv 4, rv 5. III, tarsus v 3, metatasrsus pv 2, rv 1 apical, d 2 apical, p 2, tibia pv 1 a pical, p 2, patella p 4 short spines in a line (left 3 only). IV, tarsus v 11, metatarsus pv 2, rv 3, tibia pv 1 apical.

Abdomen dorsally long bristles and hairs, very dark, with pale speckles and posteriorly with pale, barely perceptible narrow bar-like marks. Internal genitalia, paired vesicles each with narrow base, spherical crowns; whole of stem and crown covered with tubercles (Fig. 17).

Diagnosis

Labium without cuspules, abdomen hirsute, dorsally dark, pattern indistinct. Paired tarsal claws all with a single large tooth (except retroclaw IV). Legs slightly more slender and more spinose than *A.victoriensis*. Internal genitalia, vesicles with spherical crowns and straight sided stems.

Other records of *Arbanitis* from Victoria

The genus is also known from Glenaladale National Park. I collected an immature female (?) with a carapace length of 5.2 mm (BYM 1972/32) from a burrow with a thin soil door on 13 November 1972.

Note

Additional specimens of further new species of *Arbanitis* from Victoria have recently been aquired by the Museum of Victoria. Descriptions of these species are in preparation (B. York Main).

Acknowledgments

I thank Dr K. Walker of the Museum of Victoria for loan of specimens. The National Parks and Wildlife Service of Victoria is thanked for permission to collect spiders in National Parks.

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The Wonders of the Weather

by Bob Crowder

Publisher: *Australian Government Publishing Service for the Bureau of Meteorology RRP $39.95 from Commonwealth Government Bookshops or Freecall to A.G.P.S. 008 020 049 or A.G.P.S. Mail Order Sales, GPO Box 84, Canberra, ACT 2601*

In the Preface to this outstanding book, the author states that meteorology is not only about weather but must embrace the study of the total environment - the land and ocean as well as the atmosphere. He set out to explain the complex, interacting processes which govern weather and climate in a manner easily understood, interesting and appealing to a wide range of readers - amateur and professional meteorologists, groups whose lives are intimately linked with the weather (aviators, mariners, farmers etc.) and especially students. Mr Crowder has succeeded admirably.

This 264-page book is divided into eleven Chapters ranging from 'The Sun, the Earth and the Seasons' to 'Myths, Facts and Fallacies' and deals with such topics as radiation, greenhouse effect, wind systems, weather maps, clouds, precipitation, cyclones, thunderstorms etc, and, of course, weather forecasting. All the complex factors are discussed in an easy-to-read, informative and mystery-unravelling style but without ignoring the existing uncertainties and short- comings.

In addition, the text is copiously illustrated with magnificent photographs, well conceived and presented drawings, charts and graphs, and the odd cartoon, consistent with the overall somewhat informal - well! not too technical anyway - style.

The book will certainly satisfy the target readership and be a boon to those who, like the reviewer, have never really come to grips with deciphering the weather map! It will also convince the sceptics that, with the aid of the sophisticated technology now available and covered in the book, 'today's four-day weather forecasts are as accurate as 24-hour forecasts were only ten years ago'.

Arthur Farnworth
The Field Naturalists Club of Victoria

Bats in Remnant Vegetation along the Barwon River, south-west Victoria: A Survey by Electronic Bat-detector

L.E. Conole[1] and G.A. Baverstock[1]

Introduction

The Barwon River rises on the northern slopes of the Otway Ranges and then flows across coastal and volcanic plains, around the base of the Barrabool Hills, through the large provincial city of Geelong, and into the Lake Connewarre estuarine system before emptying into Bass Strait at Barwon Heads on the Bellarine Peninsula. In the headwaters, the East and West Barwon River branches begin in, mostly intact, indigenous, wet sclerophyll forest and cool temperate rainforest. As the river leaves the Otways' northern slopes, the remainder of the river's course flows through cleared rural, rural residential and urban environments. A narrow riparian strip of River Red Gums *Eucalyptus camaldulensis*, only one or two trees wide, is the sole surviving indigenous vegetation for much of the length of the river across the plains, until it reaches the marshland and White Mangroves *Avicennia marina* of the estuarine system. Other tree species in the riparian strip include Manna Gum *E. viminalis*, Late Black Wattle *Acacia mearnsii*, Silver Wattle *A. dealbata* and Blackwood *A. melanoxylon*; major shrubs include River Bottlebrush *Callistemon sieberi*, Blackthorn *Bursaria spinosa*, Hemp-bush *Gynatrix pulchella*, Tree Everlasting *Ozothamnus ferrugineus*, Tangled Lignum *Muehlenbeckia florulenta* and the exotic Boxthorn *Lycium ferocissimum*.

The broad objective is to compile an inventory of microchiropteran bats (microbats) of the Geelong-Otway area. However, we have been largely prevented from surveying bats by normal direct methods e.g. trapping and netting along major watercourses such as the Barwon, Moorabool and Leigh Rivers. This has been due to the difficulty of access, ill defined bat flyways and the serious risk of vandalism to the highly visible equipment as well as other interference by members of the public, all of which have been disincentives. We considered hand held, electronic bat-detectors as a possible solution to some of these survey impediments and in late winter/early spring (August and September) of 1994, we conducted a brief, unstructured pilot project using bat-detectors to survey microbats at arbitrarily selected points along the Barwon River between Geelong near the estuary and Winchelsea on the plains.

There are no existing written records of bats occurring in the riparian vegetation of the Barwon River near Geelong, but based on trapping in other remnant vegetation on the plains nearby, we expected to record White-striped Freetail-bat *Tadarida australis*, Little Forest Bat *Vespadelus vulturnus*, Southern Forest Bat *V. regulus*, Large Forest Bat *V. darlingtoni*, Gould's Wattled Bat *Chalinolobus gouldii*, Chocolate Wattled Bat *C. morio* and Lesser Long-eared Bat *Nyctophilus geoffroyi* (Baverstock and Conole 1991; Conole and Baverstock 1985; 1992; *unpubl. data*). We have trapped Little Freetail-bat *Mormopterus planiceps* (small penis form) and Inland Broad-nosed Bat *Scotorepens balstoni* on farmland at Teesdale on the plains (Conole and Baverstock *unpubl. data*), and expected that the plains section of the river might yield these taxa. Other possible occurrences included *M. planiceps* (long penis form) and Eastern Broad-nosed Bat *S. orion*. Other bats of uncertain status in River Red Gum riparian vegetation in this area include Eastern Great Pipistrelle *Falsistrellus tasmaniensis*, Large-footed Myotis *Myotis adversus* and Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* (Conole and Baverstock 1985; *unpubl. data*).

Methods and materials

A number of locations along the Barwon River were selected for ease of access, such as road bridges, pedestrian and bicycle paths

[1] 2/45 Virginia Street, Newtown, Victoria 3220.
[2] 1350 Noyes Road, Lethbridge, Victoria 3220.

(see table 1). At each site, a 30-40 minute period after dusk was surveyed for microchiropteran bats using one hand-held ANABAT 2.0 electronic bat-detector (Titley Electronics, Ballina, New South Wales, Australia). Inaudible (to human ears) ultrasonic calls were detected by the ANABAT, and recorded on audio cassette tape for later analysis. Recorded sequences were viewed and analysed using the ANABAT 5.1 signal processing software (Titley Electronics) on an IBM-clone personal computer. The software produced graphical representations of the microbat calls, with frequency on the y axis and time on the x axis (see figs. 1 - 3). Reference sequences were not available from the Barwon River strip, so sequences from nearby in Victoria and elsewhere were employed.

Table 1. Results of dusk bat-detector surveys at selected sites on the Barwon River Victoria.

Key:
1. Zillah Crawcour Reserve, Newtown.
2. Merrawarp Road bridge, Ceres.
3. Pollocksford bridge.
4. Winchelsea-Deans Marsh Road bridge, Winchelsea.
5. Balyang and Yollinko Sanctuaries, Princes Bridge, Newtown.
6. Buckley's Falls Regional Park, Highton.
7. Confluence of Barwon and Leigh Rivers, Inverleigh.
8. Murgheboluc.

	1	2	3	4	5	6	7	8
Tadarida australis	●		●					
Mormopterus planiceps	●					●	●	
Scotorepens orion			●					
Falsistrellus tasmaniensis			●					
Vespadelus vulturnus	●		●	●		●	●	●
V. darlingtoni/regulus	●	●	●	●	●	●		●
Chalinolobus gouldii				●	●		●	
C. morio	●							●
Myotis adversus			●					
Miniopterus schreibersii	●			●				
Nyctophilus geoffroyi	●		●					●

Results

The pilot project using the ANABAT 2.0 bat-detector was very successful, resulting in the detection of between eleven and thirteen species of microbats along the course of the Barwon River. As the sole indigenous woodland vegetation for much of the river's course, the riparian strip appeared to function as a focus for microbat activity, both for roosting and foraging. Bridge structures and aqueducts were important roost sites too, although over-represented in the survey due to our method of site selection. In an unseasonally warm and dry winter, microbat activity was greater than we expected for this time of year in a cool temperate area.

The expected species were recorded, and in some cases in areas where we did not expect them. All records were the first for the Barwon River strip, and several were significant range extensions for some species. As expected, *T. australis, C. gouldii, V. darlingtoni, V. regulus* and *V. vulturnus* were ubiquitous. *Nyctophilus geoffroyi* was not often recorded, but as a 'whispering bat' (soft calls difficult to detect) we expected to under-record it. *Chalinolobus morio* was less widely recorded than expected. We are currently not able to differentiate between *V. darlingtoni* and *V. regulus* calls, but enough variation was recorded to suggest that both species were detected. *Mormopterus planiceps* was recorded in the urban river suburbs of Geelong for the first time, as well as other new locations along the river. Two slightly differentiated call signatures were recorded from free flying *M. planiceps* at ~27 kHz and ~29 kHz, which may represent the two undescribed taxa (species 1, long penis; species 2, short penis), or simply individual variation. *Scotorepens orion* and *Myotis adversus* were recorded for the first time in the Geelong area at Pollocksford, at the base of the Barrabool Hills. Along with these tree-hole roosting species, the cave roosting *M. schreibersii* was an unexpected resident of the strip; probably roosting in aqueducts and bridge structures. Some detector records were verified or augmented by

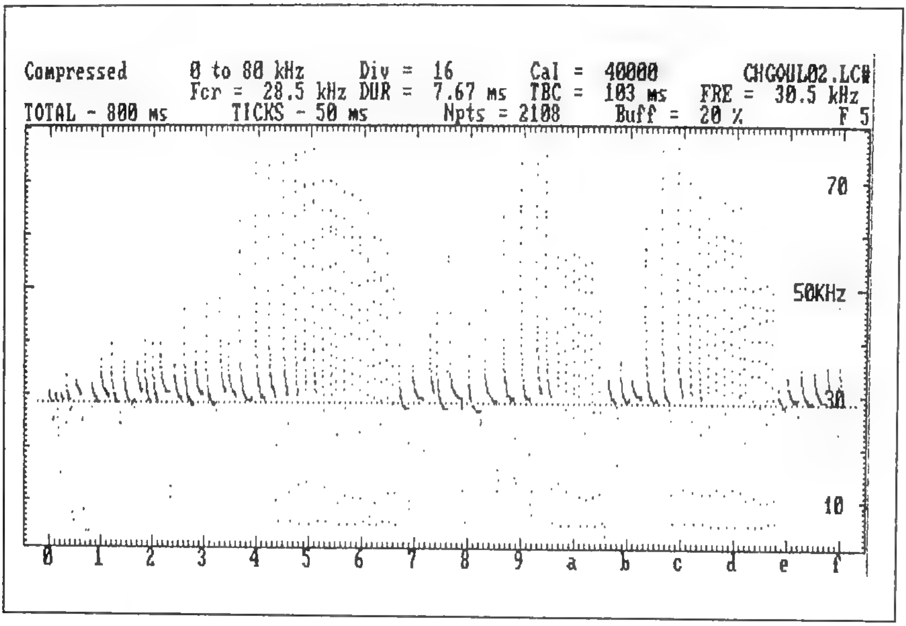

Fig. 1. Foraging sequence of Gould's Wattled Bat *Chalinolobus gouldii* showing three 'kills' or attempts to capture prey, recorded at Yollinko Sanctuary, Barwon River, Newtown (Geelong) by L.E. Conole. ANABAT V display, compressed mode (Titley Electronics).

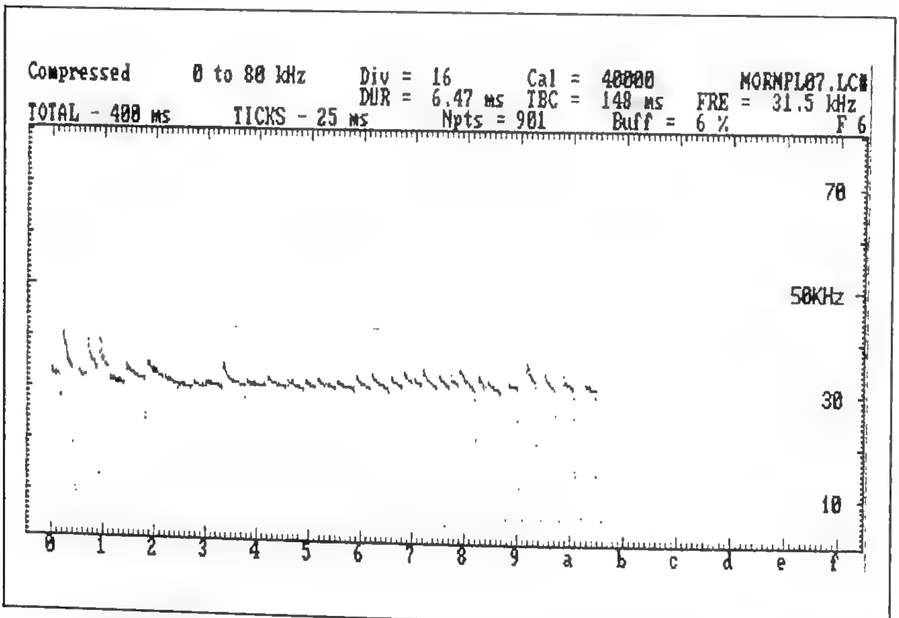

Fig. 2. Interrogative sequence of the Little Mastiff-bat *Mormopterus planiceps* recorded on the Leigh River near confluence with Barwon River, Inverleigh, by L.E. Conole. ANABAT V display, compressed mode (Titley Electronics).

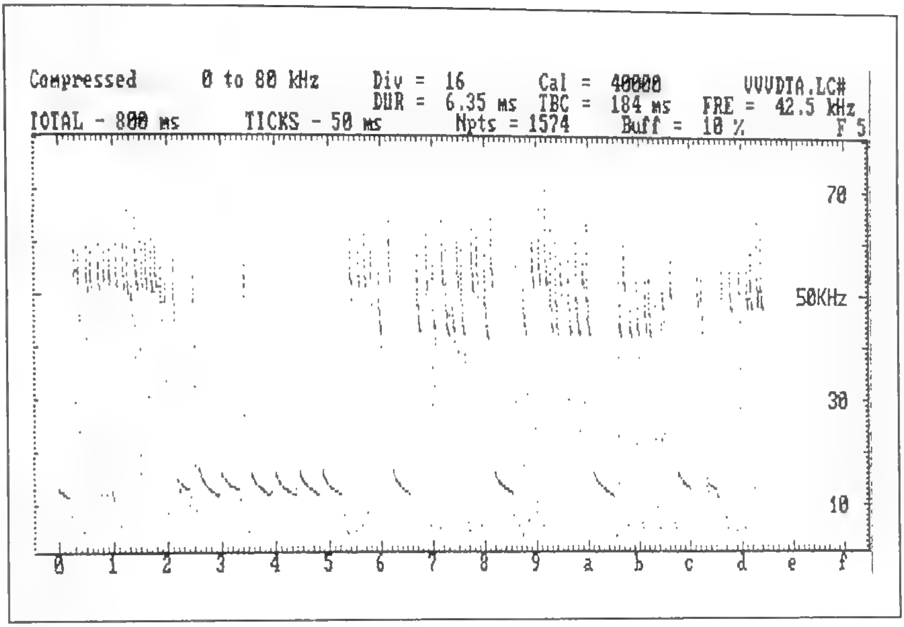

Fig. 3. Combined sequences of Little Forest Bat *Vespadelus vulturnus* (c. 50 kHz), Forest Bat sp. *V. darlingtoni* or *V. regulus* (c. 45 kHz) and White-striped Freetail-bat *Tadarida australis* (c. 12 kHz) recorded at Pollocksford, Barwon River, by L.E. Conole. ANABAT V display, compressed mode (Titley Electronics).

visual records, e.g. *C. gouldii, M. schreibersii, M. planiceps.*

Discussion

Remote sensing with bat-detectors proved to be a valuable technique for surveying a rich microbat habitat which could not easily be surveyed by direct trapping methods. A wider range of species was detected than that which occurs in any woodland remnant nearby on the plains (Conole and Baverstock 1985; 1991; 1992; *unpubl. data*). Clearly a combination of direct and remote techniques is preferable for producing verified records, and gathering morphometric and reproductive data, but the bat-detector enjoys a clear advantage in gathering basic distributional data in certain difficult survey environments.

Acknowledgments

We would like to thank Alex Kutt, Alexander Herr and Martin Rhodes for the ANABAT reference files that they provided. We also extend our appreciation to the trustees of the M.A. Ingram Trust who authorised a substantial financial contribution enabling us to purchase the ANABAT 5.0 bat-detector system.

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Initial Results from Bat Roosting Boxes at Organ Pipes National Park

Robert Irvine[1] and Robert Bender[2]

Background

The Organ Pipes National Park is located 26 km NW of Melbourne. The park is a spectacular example of restoration of natural vegetation, begun in 1972, that has rehabilitated a barren and weed-infested landscape (Kemp and Irvine 1993). The Friends Of Organ Pipes (FOOP) are involved in this revegetation effort and also in encouraging animals back into this regenerated environment.

Early mammal survey

In February 1988, Ray Brereton and Martin Schulz of the Arthur Rylah Institute (Department of Conservation and Natural Resources - DCNR) conducted a mammal survey at the Organ Pipes National Park and reported that bats were the most diverse group of native mammals occurring in the park (Schulz and Brereton 1988). Brereton and Schulz set up harp traps over Jacksons Creek and over three nights they trapped a total of 53 individual bats consisting of six species: Gould's Wattled Bat, Chocolate Wattled Bat, Lesser Long-eared Bat, Large Forest Bat, Southern Forest Bat and Little Forest Bat (Table 1). An additional species, the White-striped Freetail-bat, was recorded in flight by spotlight.

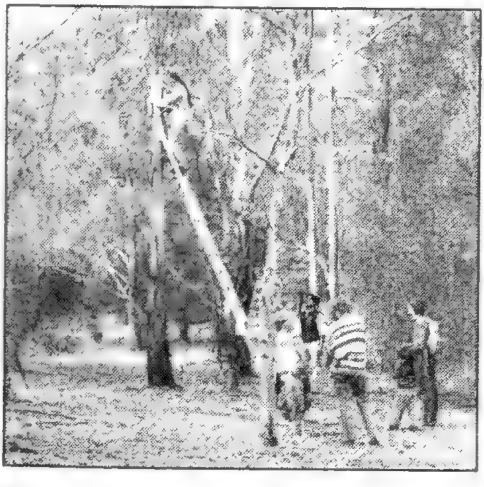
One of their recommendations was that 'To encourage bats further into the area, the possibility of setting up 'bat roost boxes' should be investigated. These have been used with great success in Europe' (Schulz and Brereton 1988).

The FOOP decided to follow up these recommendations with a project to build and install roost boxes, then undertake a monitoring program. The project started with an invitation to Ms Lindy Lumsden, also of Arthur Rylah Institute, assisted by other DCNR staff, to do some bat-trapping in the park. This helped us decide where the roosting boxes would be located.

Trapping was conducted on 3 April 1992 using two harp traps set up along the river track in the area where we proposed to locate the boxes. A total of 23 individuals from four species (Gould's Wattled Bat, Chocolate Wattled Bat, Large Forest Bat and Little Forest Bat) were caught, identified, measured, sexed, weighed and released (see Table 1).

The White-striped Freetail-bat usually forages above the canopy and well above the height of the harp trap, hence they are rarely trapped, but may use the roosting boxes.

Although it is difficult to estimate overall bat numbers from trapping data, it provided an indication of the range of species found in the area. Following the success of this second trapping session it was decided that this part of the river flat would be a good place to locate the roosting boxes. The FOOP successfully applied for a Bird Observers Club of Australia grant to construct ten roosting boxes. The timber used was *Pinus radiata*, which has weathered remarkably well over three years. The rear plate of the box



Habitat and bat roosting box location along river track.

[1] 11 Mudie Avenue, Sunbury, Victoria 3429.
[2] 9 Bailey Grove, Ivanhoe, Victoria 3079.

Table 1. Bat species and numbers trapped at OPNP.

Species	Common name	Sex	23/2/88	24/2/88	25/2/88	3/4/92	Total
Chalinolobus gouldii	Gould's Wattled Bat	M	1			1	2
		F	1				1
Chalinolobus morio	Chocolate Wattled Bat	M	3	4		1	8
		F	5	1		1	7
Nyctophilus geoffroyi	Lesser Long-eared Bat	M		1			1
		F		1			1
Vespadelus darlingtoni	Large Forest Bat	M	3	3		1	7
		F	2	1		3	6
Vespadelus regulus	Southern Forest Bat	M		1			1
		F	1	1			2
Vespadelus vulturnus	Little Forest Bat	M	6	6	1	5	18
		F	6	5		3	14
Tadarida australis	White-striped Mastiff Bat			Spotlit in flight only			

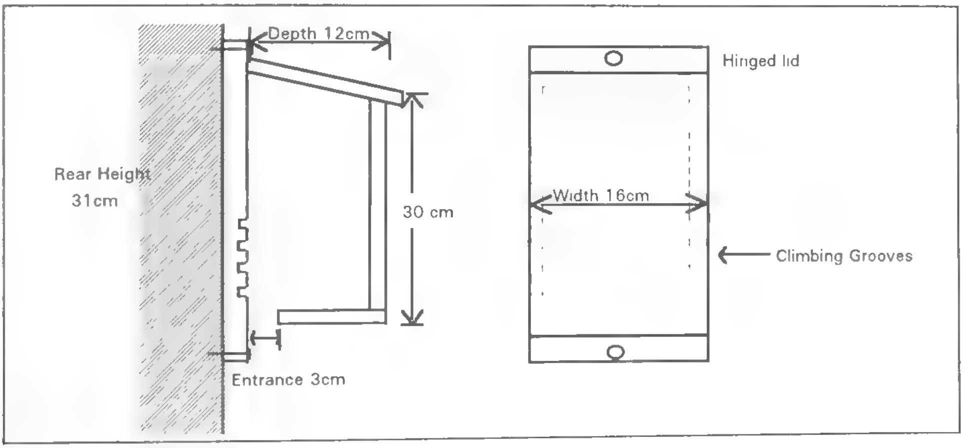


Fig. 1. Dimensions of Bat roosting boxes.

extended above and below the box structure, and was nailed to the tree trunk at both ends (Fig. 1 and Llewellyn 1988).

Bat roosting box design

The species of bats caught in OPNP predominantly roost in tree hollows or behind loose bark (Schulz and Brereton 1988). The optimum roosting box simulates these kinds of roosting sites. As there was no published research on roosting boxes in Australia, overseas research was used to determine the size and design of the boxes. We selected a design (Fig. 1) based on successful European Bat box similar to our bird boxes but without a base or round entry hole at the front. This design was to make the box dark and to enable bats to enter from below. A series of grooves was machined on the inner surface of the rear plate to make it easier for the bats to climb and cling to the boxes. It was hoped the design would also restrict use of the boxes to bats, as it was believed that other arboreal animals such as possums and birds preferred a side entry, as used on nesting boxes for birds and Sugar Gliders also set up along the creek in the National Park.

Box Location

A range of factors was taken into consideration in deciding on the placement of the roosting boxes. Trapping had shown several species were using the forested area by Jacksons Creek (Table 1). It was decid ed to place boxes about 5 metres above ground, in trees free from crowding branches, sheltered from wind and with a variety of aspects to cater for seasonal temperature variation. Ten boxes were installed in trees on 3 April 1992 in the locations shown (Fig. 2 and Table 2).

Monitoring Inspections, Don't give up hope!

Inspections were conducted in November 1992 and July, October and November 1994. Until the last inspection in November, no bats were found to have been using any of the boxes and we had come to believe the boxes were unsuccessful, for causes unknown. Possible explanations considered were that the designs were unattractive to bats, box locations were poorly chosen, and the abundant presence of natural hollows were chosen by bats in preference to our artificial boxes.

FOOP were also surprised to find that a number of the roosting boxes had been used by Sugar Gliders *Petaurus breviceps* as shown by the worn entrance where Gliders had squeezed through the narrow slit. Published illustrations of bat roost box designs (e.g. Llewellyn 1988) recommended a

Table 2. Box Installation notes and location details.

Box no	Height (metres)	Tree species	Aspect	Sun/ Shade	Comments
C1	4.5	Manna Gum *Eucalyptus viminalis*	N	Partial sun	Surrounded by trees
C2	4	Yellow Box *Eucalyptus melliodora*	SE	Shaded	Hillside close to large open area, Ridge Track
C3	4.5	River Red Gum *Eucalyptus camaldulensis*	N	Sun/ Shaded	Surrounded by trees
C4	4.5	River Red Gum	S		Surrounded by trees
C5	4.5	Manna Gum	SE	Shaded	Surrounded by trees
C6	6	River Red Gum	W	Shaded	Surrounded by trees
C7	4.5	River Red Gum	NE	Shaded	Surrounded by trees
C8	6	River Red Gum	NW	Sun/ Shaded	Near creek, surrounded by trees
C9	4.5	River Red Gum	SE	Shaded	Surrounded by trees
C10	4	River Red Gum	NW	Shaded	Overhanging creek

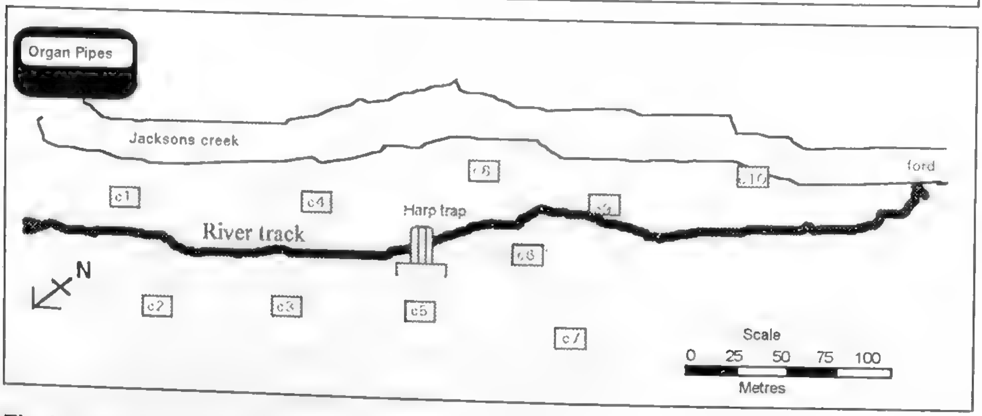


Fig. 2. Location of Bat boxes.

slit dimension of 15 to 20 mm, but we had used 30 mm, apparently allowing larger animals to enter. Two bat roosting boxes contained nests made of eucalypt leaves woven into a hollow ball that is typical of glider nests (Triggs 1984). In the three years before the bat roost boxes were installed, a program of Sugar Glider releases had taken place - 37 Gliders in total; 13 in February 1989, 6 in March 1990, and 18 in April 1990 (FOOP 1989, 1990a, 1990b).

The specifically designed boxes installed for these gliders, were mainly hollow logs with both ends bunged up and a round side entrance which was drilled through the timber. Sugar Glider use of the bat roosting boxes with the narrow slit underneath was unexpected. During 1994, a research project had commenced on social inter-action among Sugar Gliders, some of which were known to be nesting in the bat roosting boxes. The researcher had placed wooden pegs just below the entrance to some bat boxes, for attachment of sensing apparatus to detect glider movements into and out of the nest boxes.

The biggest surprise came on 19 November 1994 when, preparing to remove and relocate the boxes, we found a total of 34 bats (species were not identified) using 5 boxes in what appeared to be a random mix of aspect, location and tree species (Table 3). In box C5 bats were roosting above the old nesting material of Sugar Gliders which was filling the entrance slit. Bat droppings were found in one additional box.

According to recently released research from North America (Tuttle and Hensley 1993) roosting boxes are normally used in the first season and, if not used within two years, will probably not be used at all. Until the November 1994 inspection, we felt justified in deciding that the boxes would never be used.

Why the slow results?

It may be that the bats were roosting, over winter, in more secure locations in tree hollows and had become more active as the weather warmed up and a plentiful supply of insects appeared, late in spring. The boxes may be too cold during winter, as is suggested by the research of Tuttle and Hensley (1993) in the USA where inland winters are generally harsher than in southern Australia. This emphasises the importance of roost sites being exposed to at least four hours of full sun during winter. All boxes at OPNP are in a densely wooded area, which is un-

Table 3. Box Inspection results (boxes installed 3/4/92)
CG = *Chalinolobus gouldii*. material = material for Sugar Glider nest (Eucalypt leaves). rt = radio detector indicating tagged Sugar Glider inside. s/glider = Sugar Glider (number in box). worn = entrance slit worn by glider.

Box no.	7 Nov 1992	23 July 1994	8 Oct 1994	29 Oct 1994	19 Nov 1994	22 Dec 1994	25 Feb 1995
C1	empty	material, fresh	material	no inspect.	2 s/gliders, large nest	material	material, some ants
C2	empty	empty	worn	no inspect.	worn, bat droppings	worn, 2 bats CG	1 s/glider, nest
C3	empty	empty	empty	7 bats	2 bats, worn	1 s/glider	18 bats CG
C4	empty	empty	empty	no inpsect.	material, fresh leaves	empty	2 bats CG
C5	empty	material, rt	material	no inspect.	2 bats, material	2 bats CG material	empty
C6	empty	empty	empty	no inspect.	10 bats	empty	1 s/glider
C7	empty	empty	empty	no inspect.	7 bats	bat droppings	empty
C8	empty	empty	empty	no inpsect.	worn, Ant nest	Ant nest	Ant nest
C9	empty	empty	empty	no inspect.	13 bats	1 s/glider	2s/gliders
C10	empty	material, 1 s/glider	material	no inspect.	1 s/glider	material	material, 1 s/glider

likely to provide this source of winter warmth for a sufficient period each day. We just do not know why it took two and a half years for bats to show signs of using our roost boxes.

All four bats found in the boxes in December 1994 were identified as Gould's Wattled Bats and it is believed those found in previous inspections were also of this species.

According to our expert Lindy Lumsden 'The most probable reason for the marked change in numbers found between November and December is that by December, the females would be using maternity roosts. It appears that the boxes are not being used as maternity roosts (the internal microclimate may not be optimal for this purpose), so this leaves only the males to use the boxes'. The other factor that might have an impact was the pegs installed beneath the entrances to boxes C4 and C10 for the purpose of research being conducted on Sugar Glider social inter-actions in the area, over part of this period. These wooden pegs - two placed about 10 cm apart across the entrance slit - would have made the bats' access to the boxes more difficult. Only these two boxes had such pegs in place and eventually bats were found occupying one of these two boxes.

Conclusions and the future

There is now no doubt that bats may use the roosting boxes in the location s where we have installed them, regardless of the aspect, position in relation to sunlight, or tree species in which they are located.

FOOP intend to construct additional bat boxes to compare the success rates of diffe rent designs and positions. The new roosting boxes will be larger with multiple internal partitions, possibly of different internal dimension, to attract smaller bats than *C. gouldii* (see Fig. 3). They will also have no bases, which we expect will discourage Sugar Gliders which will have no support on which to construct their nests of eucalypt leaves. These designs have been very successful in North America.

We hope these new boxes will be suitable for the bats during winter hibernation as well as at other times of the year. They will be checked on a regular basis and all bats will be banded to investigate the social organisation of the bats. To date, all bats found using the boxes and identified to species have been Gould's Wattled Bats *C. gouldii*, despite the fact that six species have been identified as using the river flat where the boxes have been installed. This is a strong contrast with the distribution of species trapped by Brereton and Schulz in 1988, in

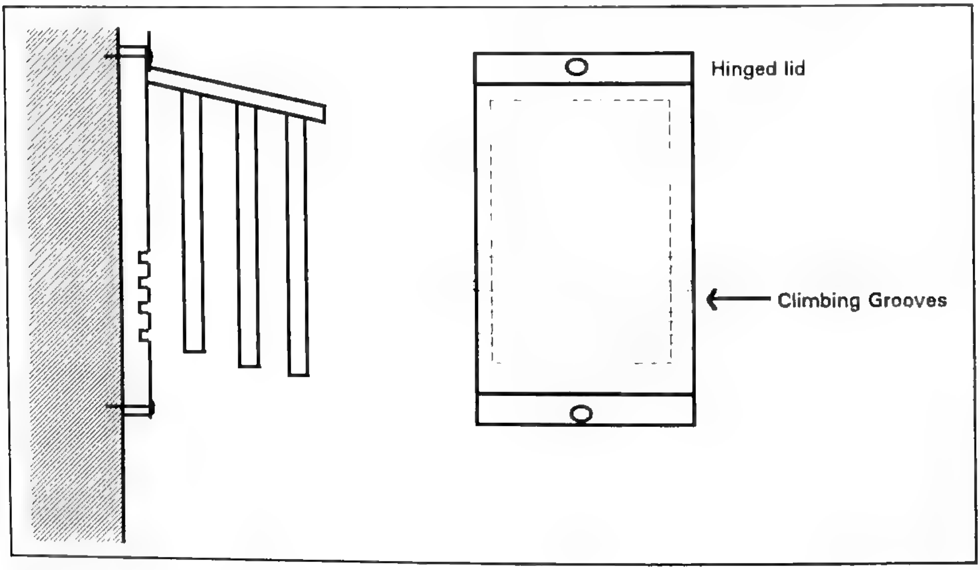


Fig. 3. Proposed new Bat roosting boxes.

which only 3 of the 53 captured bats were Gould's Wattled Bats, though harp traps might not give a representative impression of the proportional mix of species in an area, and *C. gouldii* may have been under-represented by that sampling technique. It is possible that installation of the boxes, so attractive to one species, may have affected the mix of species using the area. The planned monthly series of box inspections through 1995 should help test this possibility. However, it is known that bats such as *C. gouldii* may forage up to 20 km from their roost sites (L. Lumsden, *pers. comm.*), so they may not be using the park for foraging, despite using it for roosting.

Further results will be published when the regular banding and monitoring program seems to warrant a further report.

Acknowledgments

Lindy Lumsden for trappings at OPNP and providing advice throughout this project. Natasha Schedvin for trapping, banding and identifying bats. FOOP members Mark Scida and John Smith for helping with box inspections. Several unidentified reviewers for their valuable suggestions.

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Flora of Victoria

Volume I edited by D.B Foreman and N.G. Walsh
320 pp. 26 x 18 cm. RRP $75.00

Volume II edited by N.G. Walsh and T.J. Entwisle
26 x 18 cm. RRP $195.00

Publisher: *Inkata Press, Melbourne/Sydney.*

During 62 years since the appearance, in May 1931, of this State's only other full-length *Flora of Victoria*, immense strides have been made in botanical exploration of the whole region, studies in its ecology, plant communities and habitats. Also, as a result of considerable taxonomic research leading to revisional work, there have been many name changes and the addition of numerous unrecorded taxa. The increase in the number of accepted species is demonstrable no more dramatically than in the orchid family - 149 Victorian species recognised in A.J. Ewart's *Flora* of 1931, 270 in the present *Flora* (1994).

Ewart had managed to squeeze his whole account into a single chunky volume of 1257 pages, selling for 25 shillings, but costs were commensurate with prices at the early years of the Great Depression. Actually, its binding was inadequate for such a weighty tome which, with frequent use, tended to fall in pieces; some owners were wise enough to get this government Printer's production split and re-bound as two separate books.

The new *Flora of Victoria* comprises four volumes of which the first two are already available - Vol. 1 in 1993 and Vol. 2 at the end of 1994. Volume 1 (A$75, as a special offer) is edited by D.B. Foreman and N.G. Walsh and is entirely introductory. In its 320 pages are ten chapters by sundry specialists - on prehistory of the flora; geology and geomorphology; climate of Victoria; botanical exploration; natural regions and vegetation; soils in relation to vegetation; use of Victorian plants by Koories; interplay of Victoria's flora with fire; rare or threatened plants; exotic flora of Victoria and its impact on indigenous biota. Presentations of all these topics are fortified by photos, diagrams, maps or tables, and they provide and admirable, if not quite comprehensive, back ground for studying the whole vascular vegetation: particularly useful are those basic sections on natural regions and classification of vegetation by B. J. Conn, soils by F. Gibbons and J. Rowan, and the exotic flora (weeds) by G.W. Carr.

Volume 2 (A$155, by special offer, otherwise A$195) is under joint editorship of N.G. Walsh who wrote the account of Poaceae (grasses) and T. J. Entwisle (responsible for the orchid family). Embracing 946 pages, it is the first of three taxonomic volumes and deals with ferns (also their allies), conifers and all monocotyledons - some 1300 species. The choice of type is good and it is generously set out, giving clarity. For each species the full binomial appears in bold-face, followed by authority and details of original publication in smaller type. Essential synonymy is given wherever necessary, and the ample descriptions are uniformly set out, with any accepted vernacular names at the end of the descriptive text. The next paragraph gives distribution both within and beyond Victoria, also flowering time, while any information on affinities, peculiarities, conservation status, habitat etc. appears in final paragraphs. Every entry has an inset line-map of the State, indicating by small blacked rectangles the known range within each 10-minute grid (about 19x15 km). Far more information is thus provided than in other comparable regional floras, e.g. New South Wales (4 vols.), South-eastern Queensland (3 vols.), Perth Region (2 vols.). In a few instances the space allocated to one species will stretch almost a full column (to page-depth); and it has been calculated that each species occupies 50% more space than in any other regional flora.

Volume 2 is copiously illustrated by excellent line-drawings to show features of diagnostic importance for most species; these drawings are chiefly by Anita Barley (formerly at the National Herbarium of Victoria) who is also artist for all 16 of the magnificent colour plates. Both covers and end-papers portray a coloured map of Victoria showing the 16 'natural regions' adopted for this State. One result of so much good-quality paper is a very heavy book - just over 3 kg - and one hopes the binding will stand up to continual usage; it certainly won't unless volumes are opened carefully while flat on a table. Unfortunately the retail price of A$195, which is three times the cost of other recent floras, places this fine book well beyond the reach of most would-be purchasers, who will need to consult it at some accessible library.

Quite obviously the print has been meticulously proof-read and contains very few undetected errors of etymology or spelling. The numerous keys (to genera, groups, species and lower taxa) all seem to work well. Our F.N.C.V.'s Botany Group devoted its meeting on 13 April last to a 'hands on' session, with co-editor Dr Neville Walsh present to demonstrate the use of keys from Volume 2 in identifying actual specimens (including some difficult grasses).

It is a pleasure to recommend such a superior work, and to congratulate Inkata Press on the high quality of their beautiful production. The Dicotyledons are due to be published as Volumes 3 and 4 (in 1996 and 1997 respectively). After three generations, Ewart would surely be astounded to peruse the descendant of his one-volume *Flora* which was reviewed by Dr C.S. Sutton in *The Victorian Naturalist* of August 1931!

J.H. Willis
102 Male Street, Brighton, Victoria 3186.

Notes on the Alpine She-oak Skink *Cyclodomorphus praealtus* in the Mt Hotham Area, Alpine Victoria with a Description of a Potential New Survey Technique

Martin Schulz[1] , Jerry Alexander[2] and Ian Mansergh[2]

The Alpine She-oak Skink *Cyclodomorphus praealtus,* previously included in the *Tiliqua casuarinae* complex has been a rarely encountered reptile, occurring above the treeline in alpine Victoria and southern New South Wales (Green and Osborne 1994). She-oak Skinks (as *T. casuarinae*) had the most disparate range of any reptile in Victoria (Fig. 1) and consequently there were suggestions for a revision of the 'species complex' (e.g. Norris and Mansergh 1981). This revision has now been completed by Shea (1995) who recognises that the animals in the alpine areas (*C. praealtus)* are distinct at the species level from populations near the coast (*C. michaeli). C. praealtus* inhabits alpine grasslands and low heathlands in the Victorian alps (McDougall 1981). At present, the *Cyclodomorphus* complex is regarded as vulnerable in Victoria (CNR 1993).

Until recently, the eight records of *C. praealtus* in the Atlas of Victorian Wildlife were limited to the specimens collected in 1971, 1977 and 1983 from the Mt Hotham, Mt Loch and Lankey Plains areas (Fig. 1) Jenkins and Bartell (1980) provide an additional record from the Buffalo National Park. Some observers suggest that the species is rare and threatened (Green and Osborne 1994; CNR 1993).

The reduced limbs, snake-like movements and rapid disappearance into its grassy habitat may result in this species being easily mistaken for a small snake (e.g. Whitelipped Snake *Drysdalia coronoides* or young Highland Copperheads *Austrelaps ramsayi*). Unlike other alpine skinks, *C. praealtus* is infrequently observed basking; the rare observations are usually made as they disappear from view into the grass tussocks or other dense ground vegetation (M. Schulz *pers. obs.*), thus giving the observer insufficient time to positively identify the animal. Cogger (1983) considered the Alpine She-oak Skink normally crepuscular or nocturnal. These factors may contribute to the low reporting rates. A new technique (described below) which facilitates hand capture, should allow easier access to the species in the wild.

Each year since 1988, the Department of Conservation and Natural Resources (CNR) and Latrobe University have conducted the Alpine Ecology Course on the Bogong High Plains. In January 1995, the course was held for the first time in Mt Hotham-Dargo High Plains area. Among the full range of ecological studies, students are taught the basics of fauna survey including direct observation and active searching for cryptic reptile species. The latter includes searching potential resting sites beneath rocks and ground debris. During these 'lessons' six Alpine She-oak Skinks were hand captured: three in alpine heathland and three in alpine grassland on Mt Hotham, Mt Loch and adjacent to the Loch car park. Of these, three were observed beneath small pieces of galvanised iron. Within 50 m of Mt Loch, one immature individual was observed under the same piece of iron on three consecutive days. Despite active searching under larger sheets of 'feral' galvanised iron (0.7 x 2.0+ m), no individuals were observed. The

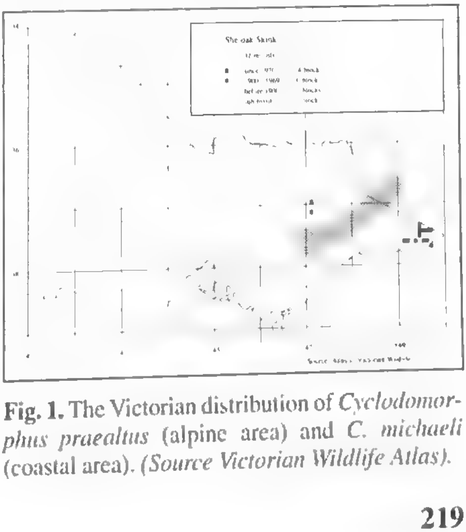

Fig. 1. The Victorian distribution of *Cyclodomorphus praealtus* (alpine area) and *C. michaeli* (coastal area). *(Source Victorian Wildlife Atlas).*

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species was not observed during the courses held on the Bogong High Plains.

These observations suggest that the species may be more common than previously thought, albeit in a quite restricted habitat. The abundance and distribution of the species needs to be clarified as a large proportion of its known range occurs within, or adjacent to, the Mt Hotham Alpine Resort. Areas of habitat may be subject to modification by infrastructure development (e.g. ski runs) for the ski industry.

Based on the above observations, a proposed survey technique for this (and other alpine reptiles) is the placement of small, about 25 x 25 cm pieces of galvanised iron within potential habitat (Fig. 2). These could act similarly to small mammal traps (e.g. Elliott traps). In this case the 'bait' is not food, but a place with increased 'protected' heat availability. The plate is laid to ensure that all edges are not flush with the ground, rather, that there are gaps to allow access. The 'trap' allows complete freedom of movement of the animal and for several animals to use it simultaneously. In the present case, the aggressive nature of the She-oak Skink, may preclude other species (Jenkins and Bartell 1980). In some environments (probably alpine) there may need to be an extended period to allow animals to find and use the 'trap' for a resting site.

Elsewhere in Victoria large sheets of iron have been used to assess the herpetological fauna during a broad-scale vertebrate survey of the Melbourne Area, District 2 (LCC 1991). Twenty (two per site) sheets of corrugated iron (240 x 90 cm) were placed in a variety of habitat types to sample the reptile population. These sheets were checked for ten consecutive days. A total of five species (32 observations) were detected utilising the shelter of these sheets during this time period (see Lumsden *et al.* 1991).

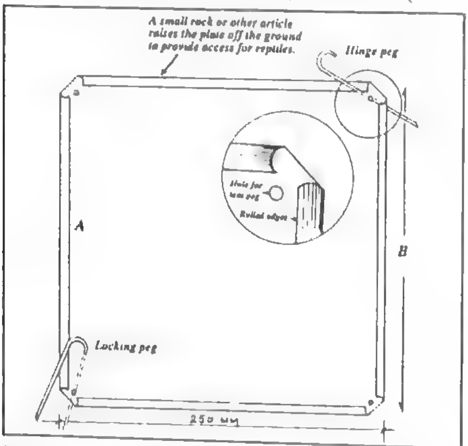

Fig. 2. Diagram of the reptile trap. To open, the locking peg is twisted and the plate raised from side A. The hinge peg when 'open' allows side B to form a barrier to movement of the animals beneath. The prototype has been developed by Elliott Scientific Instruments (Upwey, Victoria).

If successful, this simple technique, using small custom built sheets, would assist with the detection of more cryptic species (including nocturnal) and allow non-intrusive access to wild animals for the collection of biological information (reproductive condition etc.). Systematic placement of these artificial shelters (e.g. in grids and lines) could provide quantitative data for computer modelling for density estimates (e.g. White *et al.* 1982) and increase our current knowledge of distribution and abundance. Given the cost-benefit and non-intrusive nature of this technique, the use of artificial shelters as a valuable survey tool should not be underestimated. An experimental program is being implemented to investigate this technique with the Alpine She-oak Skink around Mt Hotham, and traps have been laid prior to winter (D. Heinz *pers. comm.*).

We would like to thank Glen Shea and Peter Robertson for some critical comments on the manuscript and Dean Heinz for taking the idea to field experimental stage.

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Mammal Survey

Arnis Dzedins[1]

Activities

Australia has a unique and varied mammal fauna that passes largely unnoticed as most of our animals are nocturnal, small and cryptic. There are surprisingly large gaps in our knowledge and amateurs have the opportunity to make a real contribution to science. Since much of the work involves trapping, which is illegal unless done under a permit (usually granted only to approved organisations), there is limited scope for individual studies. By far the best approach is to join a group, where experienced naturalists will help you to learn the appropriate survey techniques and pass on their knowledge about the animals concerned. Surveys may involve one-day (or night) trips as well as trapping camps spanning a weekend or longer. By participating in these you will have the opportunity to see many of our mammals at close range, particularly the smaller species which you are very unlikely to see otherwise. Some surveys are in particularly interesting areas which have limited public access. Much survey work is done at the request of the Department of Conservation and Natural Resources and by participating you would be making a direct contribution to the management and conservation of our fauna.

Methods

Direct observation is limited to a few of the larger species such as kangaroos and wallabies which are active for at least part of the day.

Stag watching involves sitting under hollow-bearing trees (i.e. potential nest trees) at dusk to observe animals coming out to feed at night. This is particularly suitable for possums and gliders.

Spotlighting is a widespread and useful technique for detecting arboreal mammals. Typically 30-55V spotlights are used with rechargeable gel cell batteries. A red filter allows more natural behavioural observations to be made, as the very bright white light often causes animals to freeze. Binoculars are also most useful.

Indirect observations, such as tracks, skeletal remains and droppings, and road kills can indicate the presence of many species. The faeces or pellets of predators (e.g. foxes, owls) often have identifiable remains (hair, bones) of small prey.

Hair tubes which contain a bait to attract the animal and a sticky tape to retain hairs are a relatively non-intrusive survey technique, but require expert microscopic analysis to identify the species. This technique is particularly useful for detecting trap shy species such as the Long-footed Potoroo and Long-nosed Bandicoot.

Nest boxes can be used as a survey tool, apart from their normal role of providing nest sites for threatened species such as the Brush-tailed Phascogale. On public land they may only be used under permit.

Trapping is by far the most useful and widespread technique for detecting small mammals. Traps are of several types: *cage traps* usually set out in a regular grid pattern and baited with an appropriate bait; *Elliot traps* - small collapsible aluminium traps; *Pit traps*, deep buckets buried in the ground, most useful for frogs and reptiles, but also suitable for some very small mammal species such as Pigmy Possums, and *Harp traps* for catching bats. All these methods are intrusive and could be damaging to the animals concerned if not done with the utmost care.

Trapping is illegal unless carried out with a permit and under the supervision of experienced personnel.

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Clubs and Societies

The Fauna Survey Group of FNCV.
Mammal Survey Group of Victoria.
Australian Mammal Society

Journals

The Victorian Naturalist publishes the results of surveys run by the Fauna Survey Group, as well as research reports by professional scientists.

Wildlife Research is published by the CSIRO and specialises in research on the biology and management of wild animals.

Australian Mammalogy is published by the Australian Mammal Society and contains articles of a specialised nature.

Enquiries

Ray Gibson is the Chairman of the Fauna Survey Group of FNCV. The Group holds meetings on the first Tuesday of each month and runs frequent surveys and trapping camps. Ray's address is:
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From our Naturalist in Residence, Cecily Falkingham

Carnivorous Plants-Carnivorous Bugs. Is There a Symbiotic Relationship?

The first time I saw a Sundew Bug, more properly a Mirid Bug (family Miridae), it was an exciting and mysterious discovery. It was the year 1985 and I was down on my hands and knees inspecting *Drosera peltata* ssp *auriculata* commonly called the Tall Sundew when it suddenly looked to me as if part of the plant had grown legs. I was, in fact, looking at a beautiful green insect with plum-coloured antennae. It had a green cross on the back of the abdomen just below the head, large compound eyes, a red, jointed proboscis which was coiled under the body when not in use. The proboscis consists of two hollow tubes, one pumps digestive enzymes down into its victim's body while the adjoining tube sucks up the pre-digested liquefied tissues. The bug also had red knees on black and white striped legs. The two long hind legs, I discovered later, made it capable of long leaps.

The opportunist in its bright-green and ruby-red 'costume' strode confidently amid the bodies trapped in the leaves of the plant. It crept up the stems, over the flowers and across the leaves without becoming trapped. Here surely was an amazing insect, immune to the Sundew's sticky leaves and with incredible camouflage.

Within the leaves of the Sundew there were a few insects in various stages of being 'eaten'. One was freshly caught by the sticky hairs on the plant. Several others were already reduced to mere shadows of their former selves. Wings that were no longer needed for flight moved gently and ineffectually as I gently blew on them. Withered and crumpled bodies soon to be blown away in the wind.

The soil where Sundews grow is usually deficient in nitrates and these insects are vital for the plant's survival. I knew that Sundews were insectivorous plants and obtained food by capturing insects, breaking them down with an enzyme into a suitable form for absorbtion. This is in addition to obtaining food by photosynthesis. In the past I had observed many small insect skeletons as well as freshly immobilised 'prey' but not once had I seen such a handsome and agile insect efficiently ignoring all the sticky leaves. What chemical did it produce on its feet to make it immune or, was it very skilful at avoiding the plant's traps?

I placed the bug and some Sundew plant in a container, large enough not to injure either specimen. Sitting at home at the dining-room table I seemed to be witnessing a miracle. How was it that the bug did not become ensnared? This bug relies on the Sundew to trap the insects on which it then feeds - a free-loader robbing the plant of precious nourishment.

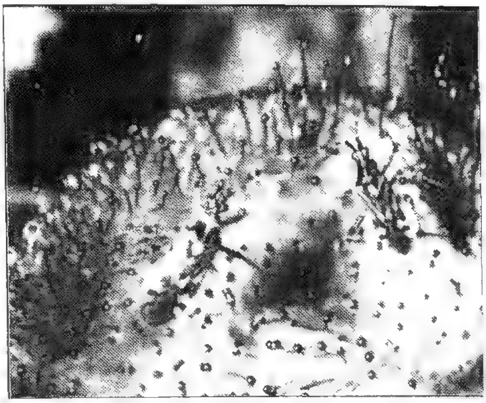

Fig. 1. Sundew Bugs on Sundew. *Photo courtesey Dr Jan Taylor.*

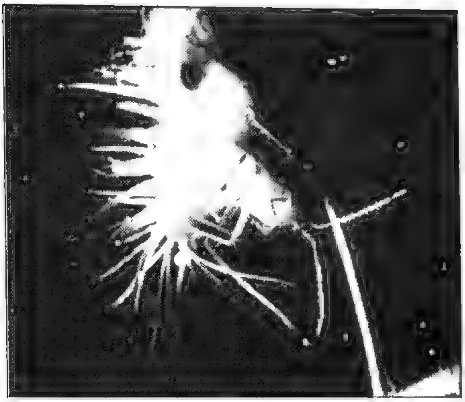

Fig. 2. Green form of Sundew Bug. *Photo courtesy Dr Jan Taylor.*

The Mirid bugs of the genera *Cyrtopeltis* and *Setocoris* have been observed feeding on the Sundew itself as well as the trapped prey (Matthews and Kitching 1984, 26). It is known that some species of Mirid bugs consume eggs of insects so providing some form of control on insect numbers.

During evolution of the species the Mirids may have started sucking sap of plants, then advanced to sucking the blood of soft-bodied insects who were themselves sap suckers.

The Black-kneed Capsid *Blephidopterus angulatus*, another Mirid, mainly preys on Red Spider Mites, a pest of British orchards. What orchardist would not welcome this species to help control at least one of the many pests that plague their life!

The Mirid bugs that I observed are only associated with Australian species of *Drosera* and do not capture their own prey. Much work remains to be done on this family.

My specimen was colour-matched perfectly to the Sundew on which it hid and, until it moved, was almost impossible to detect. In fact, the colour of these bugs varies from red to green depending on the general colour of the Sundew which in turn depends on where the plant grows - sun (red) or shade (green).

Figs. 1 and 2 show West Australian species and the colour variation.

Is the bug's relationship with the Sundew symbiotic? I wonder if ALL of the insects that are trapped by the plant's sticky hairs are digested? If not, this makes easy pickings for the Sundew Bug. Does this bug actually help the plant by quickly moving in and killing insects the moment that they arrive, and, does this killing and breaking down of the food assist the plant to obtain food? Does the Sundew Bug assist pollination or is the bug just another fascinating co-existing evolutionary phenomenon - a freeloader, robbing the larder of the Sundew?

In the quest for knowledge and understanding I am constantly overwhelmed and fascinated with how much there is to learn and observe. Additional information from Gerry Cassis of the Australian Museum showed that these bugs are only associated with Australian Sundew species and that this particular bug is an 'undescribed species' for which few records exist from Victoria.

This shows the great value of observation and keeping field notes. You never know what you may be observing and describing.

Aknowledgements

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The Editors would like to wish all their readers, authors, referees, proof readers and advisory group a very Merry Christmas and a Happy and Successful 1996, and we hope to hear from you in the New Year.

THANK YOU FROM THE EDITORS

Ed and Pat Grey wish to thank all the authors and referees for their support, time, courtesy and assistance in preparing articles for *The Victorian Naturalist*.

We would particularly like to place on record thanks to our conscientious group of proof readers for their invaluable help.

Finally, we must mention the advisory group - Gill Earl, Ian Lunt, Ian Mansergh and latterly Tom May. Their expertise and contacts in the field have been of great help to us.

The efforts of all these people have helped to maintain the quality and reputation of the journal and we look forward to their support in the future.

Our Naturalist in Residence

This has been a very interesting series and shows how valuable accurately recorded observations can be and how this sort of information is a useful contribution to overall scientific research.

Ed and Pat Grey wish to thank Cecily Falkingham for her great contribution to the journal. She has set a standard for all who follow.

We now welcome Glen Jameson who will take up this segment for 1996 - you will remember 'The Rare White Bird' and other articles by Glen. His contributions will be eagerly awaited.

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VALE JIM WILLIS

We regretfully report the death of Dr J.H. Willis. A.M. on Friday 10 November. Jim will be greatly missed personally, and for his contribution to the Club. His record number of articles in *The Victorian Naturalist* stands as a tribute to his enthusiasm. We extend our deepest sympathy to Mrs Willis and his family.

Foraminiferans from Lake Connewarre, Victoria

K.N. Bell[1]

Abstract

A live foraminiferal fauna of eleven species is recorded from Lake Connewarre and the Lower Barwon River. There is no vascular plant growth within the Lake and this together with a high turbity of the waters and varying salinities has limited the foraminiferal fauna. One new species, *Miliammina edens*, is described.

Introduction

About 10 km south of Geelong the Barwon River passes through an extensive reedy swamp area before entering Lake Connewarre - '... as picturesque a sheet of water as ever I beheld' (Lang *in* Campbell 1894). The Lake, which forms part of the Lake Connewarre State Game Reserve (3,300 ha), covers an area of some 1,000 hectares before it is drained by the Lower Barwon River via a winding channel which enters the sea at Barwon Heads (Fig. 1).

The waters of the lake are brackish as it lies within the tidal influence zone, so it is classed as an estuarine lagoon. The salinity varies with the state of the tide and the degree of freshwater input from the Barwon River; it ranges from about 4 parts per thousand near where the Barwon enters, to about 26 ppt near the Lower Barwon exit from the lake (Rosengren 1973). The tidal range is small, probably less than 300 mm but it can be greatly influenced by winds.

The lake is quite shallow - '... a pleasanter and *safer* watercourse can nowhere be found ... the bottom is so near the top' (Campbell 1894). In the early days of settlement yachting regattas were held on the lake until siltation caused the water to become too shallow (Balfour-Melville 1984). Coulson (1935) has shown that the average depth at the present, away from the river channel, is little more than one metre. Sedimentation has deposited over 10 metres of Recent sands and muds on parts of the lake floor, of which about one metre has been deposited since European occupation (Coulson 1935). Although some of this 'European' siltation is due to erosion after land clearance, much came from the sludge and tailings of the Ballarat goldfields where, from about 1856-1887, it is estimated that '80,000,000 cubic yards' of sludge had found its way into the Yarrowee (Leigh) River, and from 1887-1909 '...at least 50,000 cubic yards of sludge and sand per year was entering the river system' (Sludge Abatement Board Reports, *quoted in* Strom 1954). This material has then been reworked down the Yarrowee and Barwon Rivers into Lake Connewarre by normal bed-load flow and by turbulent flow during flood times.

The natural history and geological setting of Lake Connewarre have been dealt with by Coulson (1933, 1935) and Rosengren (1973). Yugovic (1985) has described the vegetation of the area and found that, whilst there was no vascular plant growth in the lake, the reserve supported a very diverse estuarine and freshwater flora. Sherwood (1988) has discussed the possible impacts on Lake Connewarre that may occur with climatic change.

On its northern side the lake is bounded by relatively steep cliffs cut into Middle Tertiary and Pliocene sediments. These cliffs may represent the position of a former coastline during the last interglacial high sea-level when the sea was about 7 m above present levels (Gill and Collins 1983). The southern side of the lake, by contrast, is bounded by flat-lying sands and muds which overlie basalts of Pliocene age and lie only a few metres above sea level. Coulson (1933, 1935) proposed that the lake was formed by basalt flows damming the ancestral Barwon River at Tait Point and Pelican Rocks; the river later cut through the bars and formed an exit to the sea at Barwon Heads.

Coulson (1935) lists foraminiferans (identified by W.J. Parr) obtained from shallow borings made over the lake floor and surrounding areas. These foraminiferans may be either Holocene or Late Pleistocene in age and of the 17 species reported by Coulson all but two are typical of fully marine environments, not the brackish conditions that occur at the present time.

The lake bottom sediment is fine grained, varying from muddy silts to muddy silty sands with a high organic content.

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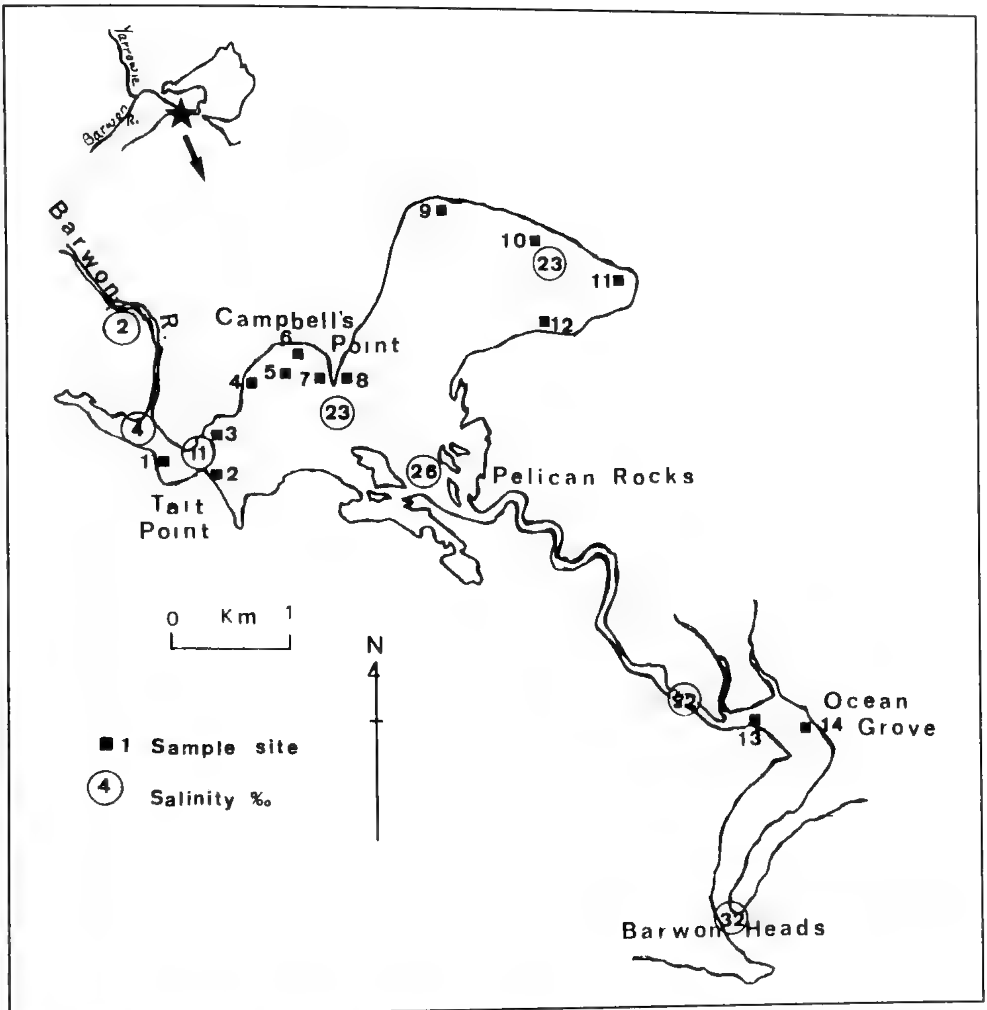

Fig. 1. Lake Connewarre, showing the sample sites and average salinity values (after Rosengren 1973).

Methods

Fifty millilitre samples of sediment were collected, and processed and picked using standard techniques. Rose Bengal was used as a protoplasmic stain to distinguish the living foraminiferans.

Results

A total living fauna of eleven species was found, comprising six agglutinated and five calcareous species. The faunal distribution by sample site is given in Table 1.

The species are well known in Victorian coastal waters and synonymies can be found in Collins (1974).

Ammobaculites barwonensis Collins 1974 (Fig. 2.2).

This species appears to be a very low salinity-tolerant form - it is very common in sample 3 whereas other samples have few, seldom live, specimens. Different salinities appear to affect the growth of this species; in the lower salinities specimens are often flabelliform, while in higher salinities the test becomes more cylindrical.

This species is widespread in Victorian estuaries in lower salinity areas such as the Gippsland Lakes (Apthorpe 1980), Mallacoota Inlet (Bell and Drury 1992) and at Western Port (*pers. obs.*).

Reophax barwonensis Collins 1974 (Fig. 2.1).

This species shows a patchy distribution apparently not related to the salinity. In higher salinity areas (samples 12,14) it grows longer and more robust.

Table 1. Distribution of foraminiferans, Lake Connewarre.
Key: ★- 1 specimen; ■ 2-4 specimens; ● 5-9 specimens; ◆ 10-40 specimens; ⊠ 40+ specimensmens

Samples	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A. barwonensis		◆	◆	■	■	■	●	●	★	◆	◆	■		
R. barwonensis		●	★	■	■	●	★	■			●	■	★	●
W. palustris		●	■		■	●		■		●	■	★	★	
T. inflata			■			●		●	■		●		■	●
M. fusca	◆	◆	◆	●	◆	●	●	◆	◆	●	◆	◆	◆	■
M. edens		◆	◆	●		●	◆	◆		●	●	◆		
Q. seminulum													◆	★
A. aoteanus	◆	◆	●	●	◆	◆	◆	●	●	◆	◆	◆	◆	⊠
E. macellum									■					
E. poeyanum	◆	◆	■	★	★	★		■			■	◆	■	●
H. depressula												★	★	◆

Warrenita palustris (Warren 1957) (Fig. 2.3).

This is a very small, slender species with slightly compressed and overlapping chambers. Rare specimens are found in many samples. This species was originally described from the Holocene marshes of Louisiana; in Victoria it is also found in Swan Bay (*pers. obs.*).

Trochammina inflata (Montagu 1808) (Fig. 2.10).

Apart from rare specimens in sample 6, this species has a patchy distribution confined to the higher salinity waters. It may be substrate controlled since the localities where it is found were those with a higher mud content as was also found by Collins (1974) in Port Phillip Bay, although Matera and Lee (1972) report its preference for coarser sediments in a Long Island salt marsh.

Miliammina fusca (Brady 1870) (Fig. 2.6, 3.4).

This species is typically found in brackish waters. It is large, with a coarse-grained but smoothly finished test surface that is often dark-coloured due to included mineral grains in the test matrix. The chambers are rounded and have a quinqueloculine arrangement. The aperture is rounded with a bar-like tooth on the inner side.

Many of the specimens from the lowest salinity samples (1, 2, 3) showed marked variations in the test growth plan with some specimens even producing a linear tube instead of the norm al chamber.

Miliammina edens n. sp. (Fig. 3.1-3).

Diagnosis: A species of *Miliammina* with a squat, oblong shape and no apertural tooth.

Types: Holotype (Fig. 3.1-2): NMV F74815, Museum of Victoria; from the Recent sediments of Lake Connewarre, Victoria; sample 3.

Paratypes (Fig. 3.3): NMV F74816, Museum of Victoria; from the Recent sediments of Lake Connewarre, Victoria; sample 5.

NMV F74817 Museum of Victoria, (10 unfigured specimens); from the Recent sediments of Lake Connewarre, Victoria, various samples.

Description: Test agglutinate, small; quinqueloculine chamber arrangement; test wall is very fine grained with much cement and a smoothly finished surface; chambers are cylindrical with almost parallel sides, rounded aborally; aperture terminal, rounded to semicircular, without a tooth; a paler rim of much finer grains surrounds the aperture; speci-

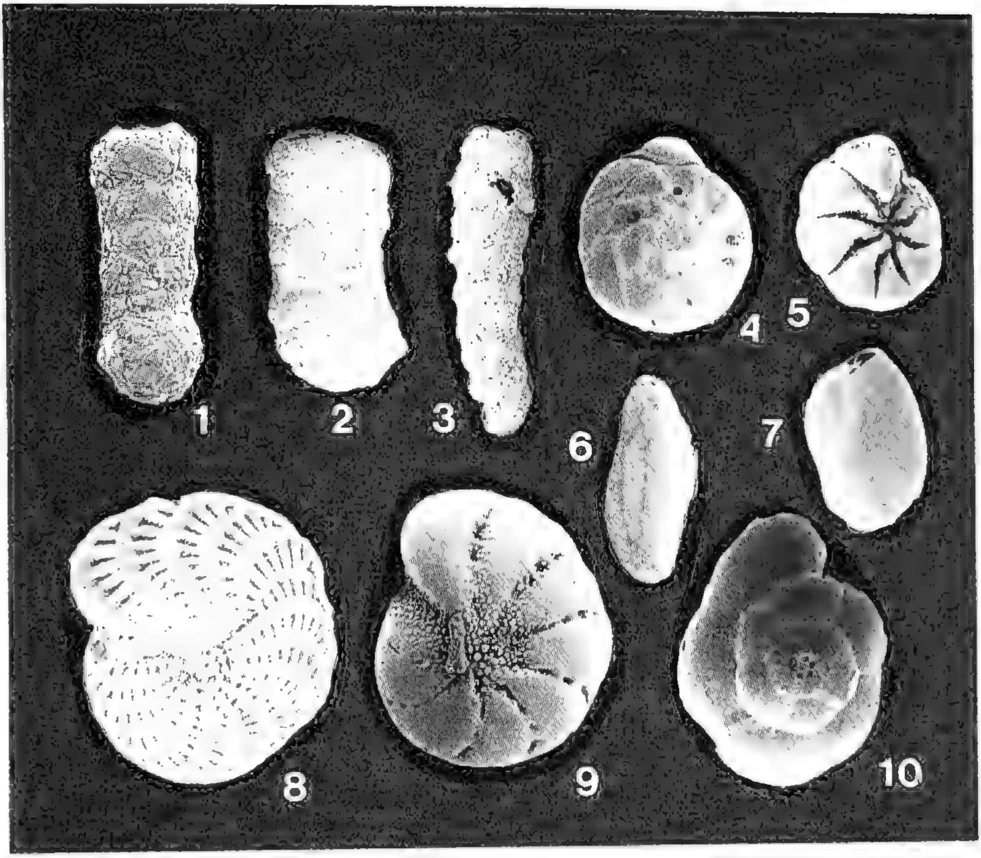

Fig. 2. 1. Reophax barwonensis x 120; 2. Ammobaculites barwonensis x 60; 3. Warrenita palustris x 100; 4. Ammonia aoteanus, spiral side x 60; 5. Ammonia aoteanus, umbilical side x 60; 6. Miliammina fusca x 45; 7. Quinqueloculina seminulum x 75; 8. Elphidium macellum x 60; 9. Haynesina depressula x 120; 10. Trochammina inflata x 60.

mens are usually a pale yellow-fawn colour when alive.

Size: Holotype (Fig. 3.1-2): length=430µm, width=276µm, l/w=1.55.

Paratype (Fig. 3.3): length=380µm, width=288µm, l/w=1.34.

Derivation of name: Lat. e - without; dens - tooth.

Remarks: One of the characteristics of the genus *Miliammina* Heron-Allen and Earland is the presence of a tooth in the aperture (Heron-Allen and Earland 1930). Notwithstanding this, the present species is placed in *Miliammina* partly because there is no other genus available and also because many authors previously have referred to specimens of another species of *Miliammina (M. fusca)* that may or may not have had an apertural tooth e.g. Brodniewicz (1965) both with and without tooth; Saunders (1958) no tooth; and the original description and figure of *fusca* by Brady (1870) with no tooth. Haynes (1973) stated that specimens from Brady's localities contain forms both with and without an apertural tooth; he suggested that the presence or not of a tooth may be a preservational artefact. Of the several hundred specimens of *M. edens* studied none had an apertural tooth. Some specimens of *M edens* become almost spiroloculine in later growth (Fig. 3.3); this is most likely due to age and not salinity changes as only a very few larger specimens showed this development.

M. edens differs from *M. fusca* in being of much smaller size; with a squat, oblong shape, having a fine-grained test and never showing an apertural tooth. Although some specimens of *fusca* may not have an apertural tooth (and these were quite uncommon in

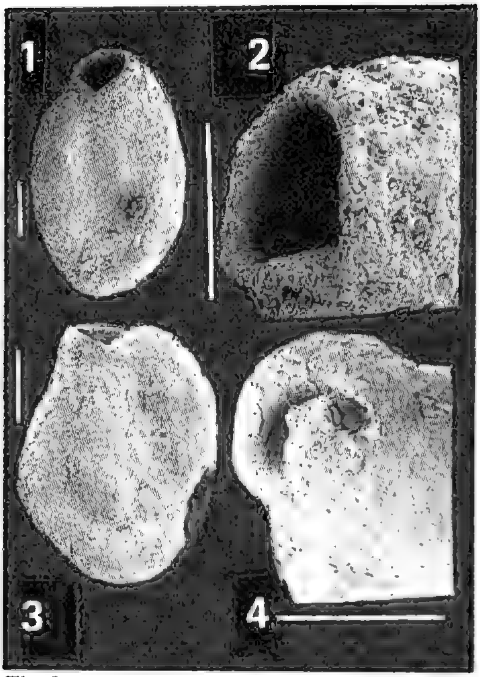

Fig. 3. 1-3, *Miliammina edens* n.sp. 1, Holotype, NMV F74815, x120; 2, close-up of aperture of Holotype, x400; 3, Paratype, NMV F74816, x150. 4: *Miliammina fusca*, close-up of aperture, x400. Scale bar: 100 µm for each figure.

Lake Connewarre) the two species can easily be distinguished on their other characters. *M. earlandi* Loeblich and Tappan differs from *M. edens* in having longer and narrower chambers, in having an apertural neck and apertural tooth and is a marine not a brackish, intertidal species.

Quinqueloculina seminulum (Linné 1767) (Fig. 3.7).

This species is only found in the Lower Barwon River downstream of the lake where the waters are almost normal marine (Rosengren 1973; salinities .32 ppt).

Ammonia aoteanus (Finlay 1940) (Fig. 2.4-5).

This is the most common species throughout the lake, although specimens are very rare and fragile in the lowest salinity localities (samples 1, 2, 3).

Elphidium macellum (Linné 1758) (Fig. 2.8).

Small, infrequent specimens are restricted to the more mobile sandy areas where little clay was present.

Elphidium poeyanum (d'Orbigny 1839)

This small, thin walled, lobate *Elphidium* is widespread throughout the lake. However, it is usually only present in rare numbers (1-5 specimens) except in samples 1, 2 and 12 where it is very common (20+ specimens). These sites have widely different salinities and the reason for the larger numbers is not known.

Haynesina depressula (Walker and Jacob 1798) (Fig. 2.9).

This species is common in sample 14, near Ocean Grove, with two isolated specimens found within the lake. This species is found widespread in Victorian shallow water sediments and previously has been recorded under the name *Elphidium simplex* Cushman 1933. It differs from true *E. simplex* in having more defined retral processes and that there is no boss in the umbilical region which, in *depressula*, is covered with small pustules which continue slightly along the sutures. Parr (1945) suggested that this form is a temperate water form of *E. simplex*.

Discussion

Although 11 species of foraminiferans are living in the lake and Lower Barwon River, the absolute number of specimens was low being of the order of 30 specimens in most samples. The reason for these low numbers may be complex. In an estuary the environmental conditions can be subject to large daily and seasonal changes which make it difficult for animals and plants to live. Within Lake Connewarre due to the high turbidity of the water and the possible mobile substrate there is no plant growth (Yujovic 1985; Sherwood 1988). This lack of plant growth within the lake is perhaps the major cause of the lower numbers since it is known that foraminiferan species are more abundant in epiphytic communities in *Enteromorpha, Zostera* beds, (Lee *et al.* 1969; Murray 1973) than in mobile sandy sediments. The turbidity of the water reduces the light intensity and so may affect the production of phytoplankton which is a major food resource for foraminiferans. Decaying plant detritus in the sediments would lead to lower oxygen levels in the substrate and in fine sediments the black sulphide layer (i.e. reduced sediments) lies close to the surface (Gray 1981). Foraminiferans are sensitive to low oxygen levels and are not found living in reduced sediments. However, these factors do not explain all the distribution variations found, although where plant growth was present (samples 2, 3) live foraminiferans were more common (about 100/sample).

Two species, *A. aoteanus* and *M. fusca*, are more tolerant of the changing environmental conditions and were found in all samples. *M. edens* is a hyposaline species found living within the salinity range 11-23 ppt. *Ammobaculites barwonensis* also shows this hyposaline distribution but was most common in the lower salinity samples (2, 3); the high numbers in samples 10 and 11 may indicate lower salinity in that area than given by Rosengren since a small intermittent stream enters near sample 11. In the estuaries of Chesapeake Bay, Virginia, the related species *A. crassus* was found to prefer low salinities and fine, organic-rich substrates, but these were not limiting conditions (Ellison 1972). Sample 9 has quite a depauperate fauna (5 species; 23 specimens); the waters of the northern arm of the lake can be more saline than the sea in summer due to the prevailing SW winds reducing water circulation (Yujovic 1985). With the higher salinity in the Lower Barwon (salinity >32 ppt) *Q. seminulum* and *H. depressula* become important components of the fauna.

To understand the patchiness and variability of the foraminiferan fauna in Lake Connewarre we need much more information on the 'microenvironment' which occurs, especially the physical and chemical factors (such as sediment size, organic content, oxygen level) and the biotic factors (e.g. phytoplankton and microbial production as foraminiferan food resources).

Acknowledgements

I thank the editors and an anonymous referee for suggestions which improved this paper.

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The Cryptogams of Royal Park, Melbourne, Victoria

Jon Sago[1]

Abstract

The cryptogamic flora of a 150 year old inner urban public reserve was surveyed and comprises twenty-one mosses, 10 liverworts and 24 lichen species. This represents 20.1% of overall plant diversity and 50.0% of indigenous plant diversity. In comparison with Yarra Bend Park, the nearest public reservation of similar size, the lower diversity values of cryptogamic species, across all groups, were attributed to recreational and topographical differences. Greatest species diversity, however, was in those remnant areas that have experienced minimal human activity.

Introduction

Royal Park, 3 km north-west of the Melbourne GPO and consisting of more than 100 ha, was reserved in 1856 with excisions for the Zoological Gardens in 1862, and railway and tramway purposes in 1889 and 1923 respectively (Sanderson 1932). A review of the geology and vascular plant ecology may be found in Carr and Race (1992) and Muyt (1991). The lack of a similar study of non-vascular plants was the impetus for this investigation.

Between April 1992 and July 1993, Royal Park was regularly surveyed and species collected and determined. An objective system of random sampling was rejected because the diverse habitats, varying from from horizontal to vertical and encompassing natural and artificial substrates, presented formidable practical problems. Instead, a subjective estimate of the frequency of each species was made derived in part from Gilbert (1990), using the scale: Abundant, Common, Frequent, Occasional and Rare (ranging from 'abundant' species which were seen constantly, to 'rare' species which were observed only once). In addition, rather than dividing the park geographically and presenting the species site by site, an ecological approach based upon community analysis was undertaken combining substrate character and humidity regimes (Ashton 1985; Mazimpaka *et al.* 1993). This was considered to give the most useful overview.

Cryptogams, throughout this article, is used as a collective noun to incorporate mosses, liverworts and lichens. Non-lichenised fungi and algae were ignored. Nomenclature follows that of Scott and Stone (1976), Scott (1985), Cropper *et al.* (1991) and Filson (1986).

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Communities observed

Turf Community

Turf habitats include roadside verges, playing fields, golf links, and other recreational areas with only occasional tree cover. These areas are all mown; cryptogam diversity and richness appear to be inversely proportional to mowing frequency.

The loose wefts of the pleurocarpous moss *Brachythecium albicans* are widespread, as with other lawn environments across Melbourne. On recently burnt soils the cosmopolitan moss *Funaria hygrometrica* is seen. Badly drained or shaded sites may also harbour the mosses *Bryum argenteum, Eurhynchium* sp., *Ceratodon purpureus* and the thallose liverworts *Lunularia cruciata* and *Riccia bifurca*.

Beneath and adjacent to *Eucalyptus camaldulensis,* the indigenous mosses *Triquetrella papillata* and *Barbula crinita* may also be encountered occupying shallow depressions that provide greater moisture availability and lesser mowing intensities.

Red Gum Grassy Woodland Community

Centred on the Upfield line rail cutting, west of Royal Park Station, this community contains both the most species (27) and the greatest number of indigenous species (24). Despite extensive clearing and past exotic uses, such as a rifle range, it comprises the highest quality extant remnant of the lower Moonee Ponds Creek valley (Carr and Race 1992). As the site has northerly aspect the cryptogam flora is restricted to that of a dry sclerophyll vascular species complement.

On bare soil and eroded areas, the mosses *Pleuridium nervosum, Archidium stellatum, Bryum argenteum* and *B. dichotomum* play a colonising role, as do the crustose lichens *Porpidia crustulata* and *Verrucaria* spp. and the thallose *Endocarpon simplica-*

tum and E. pusillum. On moister, shaded sites the lichens *Cladonia* spp. in a non-fruiting condition, and liverworts *Riccia bifurca* and *R. cartilaginosa* can be observed growing on undisturbed pluvial mud and silt.

The prominent mosses *Bryum billardieri, Campylopus clavatus, Barbula crinita, Polytrichum juniperinum, Triquetrella papillata, Weissia controversa* and *Hypnum cupressiforme* are associated with the dominant trees *E. camaldulensis* and *Acacia mea rnsii* and grasses *Danthonia, Stipa* and *Elymus.* The liverworts *Fossombronia intest*inalis and Lethocolea pansa are restricted to this community, as are the lichens *Heteredea muelleri, Ramalea cochleata, Thysansothecium hookeri* and *Cladia aggregata.*

One of the Verrucaria sp. is unnamed (P. McCarthy *pers. comm.*), whilst *Thysanothecium hookeri* is considered uncommon (Sammy 1992) and its occurrence at Royal Park is regionally significant. (Leigh *et al.* 1984).

Saxicolous Communities

Saxicolous environments are the most diverse habitats at Royal Park, encompassing artificial and natural substrata. These include exposed Tertiary bedrock, exogenous boulders, stones, brick and stonework, monuments, roofing and masonry. Due to radical alteration of the park few undisturbed rock surfaces remain and it is the artificial constructions, often over a century old, that show the greatest cryptogam richness.

The crustose lichen *Candelariella vitellina* is ubiquitous, even in the most exposed sites, and is easily detected by its yellow patina. Substrate preference is conspicuous, as granite an acidic substrate, appears to be far less amenable to colonisation than bluestone, a basic substrate. Other crustose genera include *Lecanora, Caloplaca, Buellia, Acarospora,* and *Verrucaria.* The foliose lichens *Neofuscelia pulla, Xanthoria parietina* and *Xanthoparmelia tasmanica* habitually grow on most types of stone surfaces. Thallus diameters of up to 30 cm. may be found, forming extensive mats of mixed species. The finest examples are those growing upon the rail bridge that forms part of The Avenue, Parkville and the exposed Tertiary bedrock of Royal Park West.

On south-facing brick walls and stonework, the mosses *Tortula muralis, Bryum argenteum* and, to a lesser extent, *Grimmia pulvinata* are prominent. The latter species is restricted to basic surfaces, especially basalt and the cement tracks of brickwork where it forms small, hoary pads.

Lignicolous and Corticolous Communities

This environment, consisting of wood, bark and their worked derivatives provides a distinctive and peculiar environment. In order of descending cryptogam diversity the tree genera *Ulmus, Fraxinus, Allocasuarina, Ficus, Eucalyptus* and *Pinus* provide the most suitable habitats. Such qualitative selectivity by cryptogams between tree species appears to be dependent upon available surface area and degree of bark deciduousness.

The most commonly encountered mosses are *Bryum argenteum, Tortula muralis* and *T. papillosa.* The more delicate liverworts *Frullania falciloba* and *Metzgeria furcata* are restricted to the darker, moister recesses of *Ulmus* bark and *Allocasuarina* butts, always under the influence of artificial watering of adjacent lawns. The crustose lichens *Candelariella xanthostigmoides* and lemon-yellow *Chyrosthrix candelaris,* the foliose lichens *Xanthoria parietina* and the blue-grey *Hypotrachyna osseoalba* often form extensive patches on *Fraxinus* and *Ulmus* bark. On tree extremities, such as twigs and small branches the lichen species *Usnea* sp. and *Teloschistes* sp. are found. In the vast majority of cases, lichens are observed in a non-fertile condition.

Worked timber surfaces encompassing buildings, fences, benches, and, surprisingly, chrome-treated pine timber, are all exploited by cryptogams throughout the park. The youngest surfaces are inhabited by colonising lichens such as *Candelariella xanthostigmoides,* whereas on older, more decayed surfaces, the foliose lichens *H. osseoalba, X. parietina* and *Usnea* sp., and the mosses *Tortula muralis* and *Bryum argenteum* appear.

Creek Community

An unnamed tributary of Moonee Ponds Creek, that flows from Melbourne Zoo under the Upfield rail line, forms a narrow creekline in the north of the park. Densely shaded by *E. camaldulensis, Pinus, Ulmus* and *Fraxinus,* it is the habitat within the park with highest humidity.

The zone directly adjacent to the water line, composed of eroded Tertiary bedrock and loose boulders, contains the saxicolous crustose lichens, *Lecanora, Buellia, Porpidia crustulata* and *Acarospora citrina*. Whereas bryophytes *Lophocolea, Marchantia, Rhacopilum* and *Brachythecium* are typically terrestrial elsewhere in the park, within the confines of the creek-line they also inhabit rock surfaces. The aquatic moss *Depranocladus aduncus,* egregiously absent from inner Melbourne's waterways, is here confined to water soaks and seepages. Higher up on the banks, the fructicose lichens *Cladonia humilis* and *C. scabriuscula* may be found in abundance. This is the only site where these species may be encountered in fruiting condition, an indication of its relative undisturbed and mesic nature. The pleurocarpous mosses *Brachythecium, Rhacopilum* and *Hypnum cupressiforme* also have high cover values. Close examination revealed small disjunct patches of the liverworts *Riccia bifurca, Lunularia cruciata, Marchantia berteroana, Cephaloziella arctica* ssp. *subantarctica,* and mosses *Philonotis tenuis* and *Eurhynchium. Brachythecium albicans* is of only recent introduction (Willis 1955) and its dominance of the habitat represents evidence of disturbance of the creek-line within the last fifty years.

Above the creek-line, but still under the influence of tree shade, is a grassy community of *Distichlis, Briza, Nassella* and *Danthonia.* It is here that *Hypnum* has the highest cover. Other mosses found growing amongst the grasses were *Barbula crinita, Triquetrella papillata* and *Bryum billardieri.*

Vitricolous and Anomalous Communities.

These communities reside on substrata that are, by definition, artificial in substance and origin. They include glass, paint, bitumen, concrete and oxidised metal surfaces. Broken, but subsequently undisturbed, beer and soft drink bottles provide a suitable habitat for *Candelariella vitellina, Xanthoparmelia tasmanica* and *Neofuscelia pulla.* Studies have shown that glass and vitreous surfaces must initially become pitted before colonisation can be initiated (Brightman and Seaward 1977). Since the examples of colonised shards that the author has collected are up to 5 cm in diameter, it can be estimated that they have been laying on the ground for periods that can be measured in decades instead of years.

Concrete less than 20 years old, particularly building masonry and footpaths, is found to be colonised with *Candelariella vitellina. Xanthoria parietina* was observed only on such surfaces older than 20 years, and then only forming small, discrete patches, less than 3 cm in diameter.

Exploiting the gaps and hollows of road metal in bitumen roads and paths, *Xanthoparmelia tasmanica* and *Neofuscelia pulla* are able to produce relatively high cover values on areas of road surface. This phenomenon, which can also be observed across Melbourne, is apparently facilitated by the greater stability and moisture retention of bitumen roads than locally available saxicolous habitats. If substrate age, aspect and absence of human activity suitably conspire, the additional species *Porpidia crustulata, Xanthoria parietina, Tortula muralis* and *Bryum argenteum* can also occur.

Aged painted surfaces on wood, metal and stonework which have decayed to the point of flaking, or with only the pigment stain remaining, may be observed to carry *Candelariella xanthostigmoides* and *Xanthoria parietina* colonies.

Discussion

The total number of plant species including vascular species (Carr and Race 1992) was found to be 274 of which 20.1% were cryptogams. Of the overall indigenous (i.e. non-introduced) plant species 50.0% were cryptogams. Table 1 illustrates the cryptogam floristics of the study area. Their figures are discussed below and those in brackets are percentages of species in common with those at Yarra Bend (Sago 1994), which, in metropolitan Melbourne, is the nearest area of remnant vegetation to Royal Park. Twenty (39%) were mosses, 23 (26%) lichens and 10 (80%) liverworts. The Royal Park's lower values across all groups is attributable to the comparative lack of topographical variety, and past and present human activity. The gently undulating topography of the Park, with only a single creek-line, allows little amelioration of the effects of solar radiation and wind. The original *E. camaldulensis* Grassy Woodland has been cleared and, with only one exception, totally transformed (Muyt 1991). This is unlike Yarra Bend where a variety of original habitats persist. Also certain substrates, such as burnt wood, are entirely lacking, while the

Table 1. Cryptogamic Floristics of Royal Park.
Key: - 1.= red gum grassy woodland community; 2.= turf community; 3.= creek community; 4.= saxicolous community; 5.= corticolous and lignicolous community; 6.= vitricolous and anomolous community.
A=abundant; C=common; F=frequent; O=occasional; R=rare., *=introduced or urban.

SPECIES	1	2	3	4	5	6
LICHENS						
Acarospora citrina			O	F		
Buellia sp.			O	F		
Caloplaca sp.			O	O		
Candelariella vitellina	O		C	A		F
C. xanthostigmoides					C	
Chrysothrix candelaris					O	
Cladia aggregata	O					
Cladonia fimbriata	O		O			
Cladonia humilis	O		O			
C. scabriuscula	O		O			
Endocarpon pusillum	O		O			
Endocarpon simplicatum	F			F		
Heterodea meulleri	O					
Hypotrachyna osseoalba.					C	
Lecanora sp.			O	F		
Neofuscelia pulla				C	R	F
Porpidia crustulata	F		O			
Ramalea cochleata	O					
Teloschistes sp					O	
Thysanothecium hookeri	O					
Usnea sp.					O	
Verrucaria spp.	O		O	O		
Xanthoparmelia tasmanica				C	O	F
*Xanthoria parietina**			O	F	F	O
MOSSES						
Archidium stellatum	F					
Barbula crinita	O	O	O			
*Brachythecium albicans**	O	A	C			
*Bryum argenteum**	C	C	F	F	O	O
Bryum billardieri	F		O			
*Bryum dichotomum**	C	C	O			
Campylopus clavatus	C	O	O			
*Ceratodon purpureus**	F	F	O			
Depranocladus aduncus			O			
Eurhynchium sp.*		O	O			
*Funaria hygrometrica**	O	O				
Grimmia pulvinata				F		
Hypnum cupressiforme	O		F			
Philonotis tenuis			R			
Pleuridium nervosum	O					
Polytrichum juniperinum	O					
Rhacopilum convolutaceum			O			
*Tortula muralis**			O	F	F	R
Tortula papillosa					O	
Triquetrella papillata	O	O	O			
Weissia controversa	O					
LIVERWORTS						
Cephaloziella arctica ssp. *subantarctica*			R			
Fossombronia intestinalis	O					
Frullania falciloba					R	
Lethocolea pansa	O					
Lophocolea semiteres	O		O			
*Lunularia cruciata**			O			
Marchantia berteroana		O	O			
Metzgeria furcata					R	
Riccia bifurca	F	O	O			
Riccia cartilaginosa	R					

recreational pressure chronically degrades habitats and their formation. As a consequence overall species diversity tends to a minimum. However the colonizing component of terrestrial bryophytes are at an adaptive advantage in such situations.

A common feature amongst some of the species present is their wide ecological amplitude, in as much as they are almost indifferent to substrate and, to a lesser extent, microclimate. The genera *Xanthoria, Candelariella, Bryum,* and *Tortula* would be included in this complement. Moreover, they are also classed as urban, cosmopolitan and early colonisers (Gilbert 1990; Mazimpaka *et al.* 1993), suggesting they are able to withstand pollution and disturbance, prominent environmental factors of urban areas.

In contrast, a group of indigenous cryptogams can be characterised by a low tolerance of disturbance a nd a dependence upon a high integrity of soil structure. In the Royal Park environment they are concentrated in refugia that have been bypassed by human destruction. The most prominent habitat form for such species is a superficial soil crust consisting of dense, interwoven cryptogam hyphae, rhizoids and associated algae, especially *Nostoc.* Unless hydrated, these crusts are present as an undifferentiated, continuous 'mat'. Such mats have been implicated in the germination ecology of native vascular plants (Scarlett 1994), and soil stability and erosion control (Eldridge and Greene 1994). Included in this grouping are the genera *Cladonia, Cladia, Heterodea, Thysanothecium, Ramalea, Lethocolea, Fossombronia, Barbula, Polytrichum, Weissia, Triquetrella* and *Philonotis.*

A further group is limited to habitats of high relative humidity, and are therfore severely restricted within the Melbourne metropolitan area. In general, and in Royal Park particularly, artificial watering regimes of public parks allow a far greater geographical range than that would naturally occur However, they tend to be tolerant of phorophyte (host tree), and include the bryophyte genera *Frullania, Metzgeria* and *Rhacopilum.*

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European Management of Remnant Grassy Forests and Woodlands in South-eastern Australia - Past, Present and Future?

Ian D. Lunt[1]

Abstract

The impact of European management practices on grassy forests and woodlands is discussed, and six conclusions are drawn: (1) On the Gippsland Plain in Victoria, the exclusive use of either grazing or burning, coupled with the effects of changing tree densities, has led to an ecological segregation of many plant species. Many species have been depleted in one class of reserves only to survive in another. Similar patterns occur in other grassy forests and woodlands in south-eastern Australia. (2) The tiny rail-line and cemetery remnants that tenuously survive in woodland regions protect a suite of species that have been systematically depleted or eliminated from the larger, secure grassy forest and woodland remnants. (3) In order to conserve the small rail-line remnants and their species, the traditional rail-line management of tree removal, grazing exclusion and frequent burning should be continued. (4) The species that repeatedly occur in rail-line or cemetery remnants were presumably common and widespread in the region originally, and most probably also occurred in grassy forest and woodland remnants that occur on similar soils. (5) Species conservation, in some cases, may be hindered at present by policies which prevent species from being introduced to secure reserves unless there are accurate records from the particular reserves. This is a problem since many species were undoubtedly eliminated from some reserves before records were made. (6) Most Victorian remnants of grassy forests and woodlands are being managed as 'grazing ecosystems' with no burning. Consequently, small-scale trials are urgently required to determine the effects on endangered species of grassy forest and woodland management regimes that are characterised by grazing exclusion and frequent burning.

Introduction

The management requirements of remnant grasslands dominated by Kangaroo Grass *Themeda triandra* have received considerable attention lately (e.g. Stuwe and Parsons 1977; McDougall 1989; Lunt 1991; Scarlett *et al.* 1992). By comparison, little attention has been given to grassy forests and woodlands. It is now widely recognised that most *Themeda* grasslands need regular management, usually in the form of burning, to maintain plant diversity. By contrast, management of lowland grassy forests and woodlands in south-eastern Australia is typically a process of benign (and malign) neglect, in which diversity is assumed, rightly or wrongly, to be maintained by internal 'natural' processes.

This article concerns the impact of European management practices on remnant grassy forests and woodlands in south-eastern Australia. It deals with three aspects. Firstly, I summarise findings from a recent study of remnants in Gippsland. This article provides an overview of these results and discusses their implications for conservation. The detailed results will be presented elsewhere. Secondly, I present a broader interpretation of these results to include grassy forest and woodland remnants throughout Victoria, and finally I present some thoughts on how such remnants might be managed in the future.

The terms 'grassy forest' and 'grassy woodland' refer to lowland (non-alpine) ecosystems on relatively fertile soils, in which the understorey is dominated by native grasses and herbs with relatively few species of shrubs (Lunt 1991). Grassy forests have a higher density of trees than grassy woodlands (Specht 1981). The term 'grassland' refers to treeless sites in which native grasses and herbs dominate the ground layer; trees are either naturally absent or may have been removed since European settlement. *Themeda* grasslands are dominated by the perennial, native tussock-grass, Kangaroo Grass *Themeda triandra*. Plant names follow Ross (1993).

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Fig. 1. Location of the study area: the lowland Gippsland Plain.

The lowland Gippsland Plain

The lowland Gippsland Plain occupies about 2000 sq km in eastern Victoria, from Traralgon east to Johnsonville (Fig. 1). At the time of European settlement, the alluvial plains probably supported about 600 sq km of native grassland and 1200 sq km of grassy forests and woodlands. The native grasslands have since been totally destroyed for agriculture and not a single remnant is known to survive (Lunt 1994). The grassy forests and woodlands have fared slightly better. The largest and most intact remnant is the nationally significant Moormurng Flora and Fauna Reserve near Bairnsdale, which includes about 400 ha of grassy forest dominated by Forest Red Gum *Eucalyptus tereticornis*. The second largest remnant, the Briagolong Forest Reserve, includes about 120 ha of Forest Red Gum forest, and there are many other smaller remnants, most of which are quite degraded. Collectively all of these remnants add up to about 0.3% of the region. Most of the region supports grazed pastures.

In first visiting the Gippsland region, I was puzzled by the presence of *Themeda* grasslands along rail-lines and in some cemeteries. These small grassland patches are in areas that were mapped in the 1860's as grassy forest and woodland, not grassland, and they often occurred in close proximity to larger remnants supporting Forest Red Gum grassy forest. However, the grassland patches appeared to have a very different floristic composition from the grassy forest remnants, even though both seemed to occur on the same soils. The rail-line grasslands and the nearby grassy forest remnants have different management histories. The grassy forest remnants have been selectively logged and most have rarely been burnt. All have been grazed by stock with varying intensities, and many are now grazed by Grey Kangaroos. Judging from the density of stumps at some sites, tree density is probably considerably greater now than at the time of European settlement. Conversely, the trees have been removed from the rail-lines and cemeteries, and these sites have not been grazed by stock or kangaroos since the rail-line was built last century. Instead, they have been burnt about every 2-4 years.

Recently, I undertook a vegetation and seedbank survey to see how distinct the grassland and grassy forest floras were, and to attempt to identify the physical and management determinants of the two floras. Only intact remnants with few weeds were sampled, not obviously degraded sites. I asked three questions: (1) Do the grassland patches on rail-lines and in cemeteries have a different floristic composition from the grassy forest remnants, or do they just have different dominant species, with the subordinate species being common to all sites? (2) Do the rail-line grasslands occur on different soil textures from the grassy forest remnants? (3) Is it possible to identify which factors are primarily responsible for any differences in floristic composition, e.g. different grazing or burning histories, or differences in tree cover?

The results of the survey were quite surprising. Firstly, grassland and grassy forest remnants both occurred across a wide range of soil textures, from heavy clays to sandy loams. Some grassland and grassy forest patches of dramatically different plant composition were separated only by a fence-line, with both communities growing on similar soils. Furthermore, the composition of grassy forest remnants on sandy soils was more similar to that of distant grassy forest patches on clay soils than it was to nearby grasslands on sandy or clay soils.

Thus, the differences between the two communities were not due to large-scale differences in 'natural' soil texture. Instead, plant composition was directly correlated with the long-term site management. Grassland remnants on the rail-lines and in cemeteries shared a similar floristic composition, regardless of the location of the remnant or the soil texture, while the grassy forest remnants shared another distinct group of species. Many species were common in both communities, but many more only occurred commonly in one community, and some species were totally restricted to one community (Table 1). Furthermore, neither community could be called a 'degraded' or 'depauperate' form of the other, as both had a similar richness of native species and relatively few exotics. The magnitude of the floristic differences between the two communities was

Table 1. Common grassland, grassy forest and widespread species on the Gippsland Plain. Grassland species are uncommon or absent in grassy forest remnants, and grassy forest species are uncommon or absent in grassland remnants. Widespread species are common in both communities. Taxonomy follows Ross (1993), and asterisks (*) denote exotic species.

Grassland species	Grassy forest species	Widespread species
Allocasuarina verticillata	*Acacia implexa*	*Aira* spp.*
Briza maxima *	*Asperula conferta*	*Agrostis avenacea*
Bulbine bulbosa	*Astroloma humifusum*	*Anagallis arvensis* *
Burchardia umbellata	*Comesperma volubile*	*Arthropodium strictum*
Caesia calliantha	*Cotula australis*	*Bossiaea prostrata*
Chamaescilla corymbosa	*Crassula decumbens*	*Briza minor* *
Chrysocephalum apiculatum	*Danthonia geniculata*	*Carex breviculmis*
Craspedia variabilis	*Danthonia racemosa*	*Centaurium erythraea* *
Diuris punctata	*Dichondra repens*	*Cerastium glomeratum* *
Drosera peltata ssp. *peltata*	*Elymus scabrus*	*Crassula sieberiana*
Eragrostis trachycarpa	*Eucalyptus tereticornis*	*Danthonia setacea*
Haloragis heterophylla	*Gahnia radula*	*Danthonia tenuior*
Helichrysum scorpioides	*Galium murale* *	*Dichelachne crinita*
Hemarthria uncinata	*Geranium potentilloides*	*Dillwynia cinerascens*
Holcus lanatus *	*Glycine microphylla*	*Eragrostis brownii*
Juncus capitatus *	*Gnaphalium involucratum s.l.*	*Gnaphalium purpureum* *
Leptorhynchos squamatus	*Hydrocotyle foveolata*	*Gonocarpus tetragynus*
Lomandra nana	*Hydrocotyle hirta*	*Hypericum gramineum*
Pentapogon quadrifidus	*Lagenifera gracilis*	*Hypochoeris glabra* *
Poa clelandii	*Leptorhynchos linearis*	*Hypochoeris radicata* *
Romulea rosea *	*Microlaena stipoides*	*Hypoxis hygrometrica*
Thelymitra spp.	*Opercularia varia*	*Juncus subsecundus*
	Poa sieberiana	*Leontodon taraxacoides* *
	Poranthera microphylla	*Lomandra filiformis*
	Ranunculus sessiliflorus	*Microtis unifolia*
	Senecio tenuiflorus	*Oxalis perennans*
	Solenogyne dominii	*Pimelea humilis*
	Soliva sessilis *	*Plantago gaudichaudii*
	Stipa rudis	*Schoenus apogon*
	Taraxacum sp. aff. *brakellii* *	*Sonchus oleraceus* *
	Veronica plebeia	*Stipa mollis*
	Viola betonicifolia	*Themeda triandra*
	Vulpia myuros *	*Thysanotus patersonii*
	Wahlenbergia gracilis	*Tricoryne elatior*
	Xanthorrhoea minor	

also surprising. The rail-line grasslands and the grassy forest remnants clearly formed two 'communities' rather than minor 'sub-communities' under the classification scheme that is widely used in Victoria (e.g. Gullan *et al.* 1981; Opie *et al.* 1984; Lobert *et al.* 1991; Frood 1992).

The Gippsland data do not reveal the causal factors for these differences – whether species are abundant on rail-lines because they require fire, or because they can't persist under dense trees or stock grazing. Different species may be affected by different factors. Unfortunately, these factors cannot easily be determined since regularly burnt, ungrazed, grassy forest remnants, or regularly grazed and burnt rail-line sites, simply do not exist. Nevertheless, the patterns of land-use on the Gippsland Plain are common throughout south-eastern Australia: intact, regularly burnt rail-line and cemetery sites tend not to be grazed and grassy forest and woodland remnants tend to have a history of frequent stock grazing but infrequent burning (see below).

'Original' vegetation

Before European settlement the grassy forests and woodlands of the Gippsland Plain formed a continuous ecosystem (Lunt 1994), not a series of tiny, isolated remnants, and the rail-line obviously didn't exist. Presumably, the species that I recorded in grassy forest remnants and in rail-line grasslands all existed in the one community originally; they could not have formed two discrete communities as they do now. Rail-line species, like the Purple Donkey-orchid *Diuris punctata*, Blue Grass-lily *Caesia calliantha* and Common Everlasting *Chrysocephalum apiculatum* (Table 1), are most likely to have occurred in the same sites as the species that are now restricted to the forested remnants, like Love Creeper *Com esperma volubile*, Creeping Speedwell *Veronica plebeia* and Small Poranthera *Poranthera microphylla*. Presumably there were small-scale patterns within the original grassy forests and woodlands, with some species being more abundant under trees and others in gaps, and some being common in dry areas and others in damp sites. But on a broader scale, the sites that now support rail-line grasslands and the sites that now support grassy forest remnants presumably all contained much the same flora 150 years ago.

Over the past 150 years the original grassy forests and woodlands have been fragmented and most have been converted to agriculture. In addition to these obvious changes, an extraordinary process of 'ecological segregation' has taken place in the most intact remnants that remain (Fig. 2). Many species have been depleted or eliminated from the grassy forest remnants and large populations of these species now only survive in sites such as rail-line verges and cemeteries. Simultaneously, another group of species has been depleted or eliminated from the rail-line and cemetery sites, only to survive in the grassy forest patches. In destroying the one original grassy ecosystem, we have created two very different plant communities: the present grassy forests and the present grasslands. We now have to conserve two communities to save the remnants of the one original community.

Future management needs

To save large populations of all native species on the lowland Gippsland Plain, the rail-line grasslands and the grassy forest remnants will both have to be protected, as many species are largely restricted to just one of the two communities. Furthermore, based on our present understanding of the management requirements of both communities, the most prudent way to conserve both will be to continue the traditional management (although the importance of marsupial grazing in grassy forest remnants remains unknown). Thus, in order to maintain the distinctive rail-line flora, rail-line remnants should continue to be regularly burnt, have large grazing animals excluded, and regenerating trees continually removed.

In another analysis, I found that most of the species that occur in both rail-line grasslands and grassy forest remnants occur predominantly in forest gaps, not beneath dense trees. Presumably, therefore, if trees are

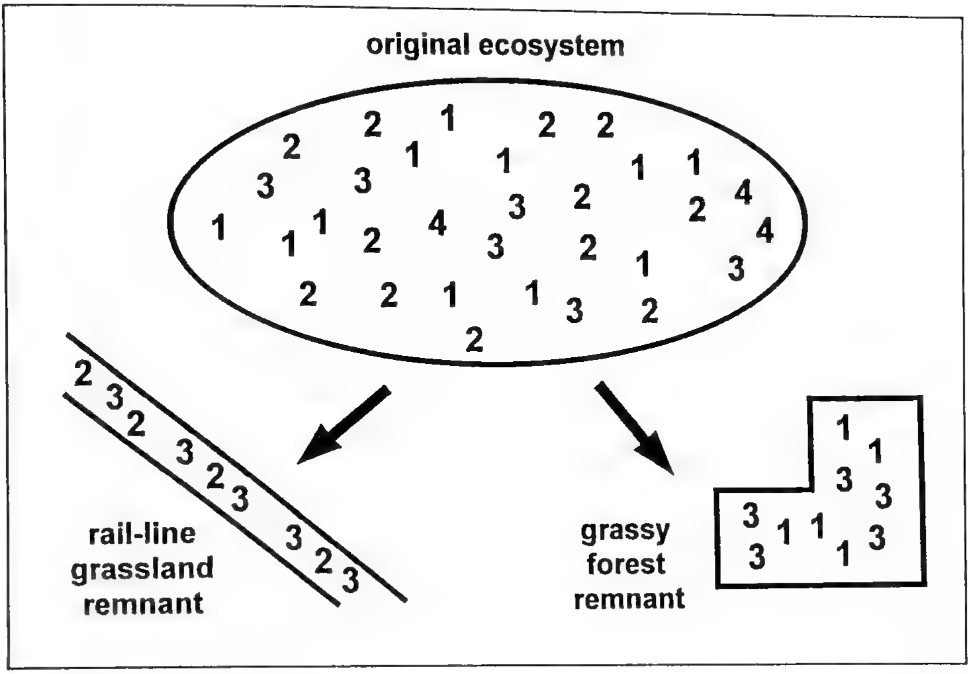

Fig. 2. Simple model of species segregation, with examples from the Gippsland Plain. The original ecosystem contained four, co-occurring groups of species (1 - 4), which suffered various fates following European settlement. Species in group 1 were depleted or eliminated from frequently burnt, ungrazed rail reserves, and now survive in unburnt, intermittently grazed grassy forest remnants (e.g. *Hydrocotyle hirta, Leptorhynchos linearis* and *Veronica plebeia*). Group 2 species were depleted or eliminated from unburnt, intermittently grazed, grassy forest remnants, and now survive in treeless, frequently burnt, ungrazed rail reserves (e.g. *Caesia calliantha, Chrysocephalum apiculatum* and *Diuris punctata*). Group 3 species remained common in rail-line grasslands and grassy forest remnants (e.g. *Arthropodium strictum, Bossiaea prostrata, Hypericum gramineum* and *Plantago gaudichaudii*), and Group 4 species became extinct in the region (e.g. *Goodenia pinnatifida, Rutidosis leptorrhynchoides* and *Thesium australe*; Lunt 1994). Some species remain common in grazed native pastures in the region, especially many of the widespread species in Group 3.

allowed to recolonise the small rail-line grassland sites, then these gap-requiring species may be lost. Many ecologists suspect that many grassland and woodland species do not form persistent, long-term seed banks in the soil (DeKock and Taube 1991; J. Morgan and A. Pyrke, *pers. comm.*, September 1992; Lunt, *unpubl. data*, August 1995). This pattern also occurs in many grasslands overseas (Thompson 1992). If this is so, such species will completely disappear from the rail-line sites when existing plants die, as there will be no seeds for future regeneration. Furthermore, there will not be a succession to a typical grassy forest flora under dense stands of regenerating trees in rail-line grasslands, as seeds of the grassy forest species do not survive in the soil beneath the rail-line grasslands (Lunt, *unpubl. data*, August 1995). Dense tree regeneration on rail-lines results in an impoverished mix of widespread, shade-tolerant natives and exotics. To preserve the rail-line flora, rail-line management should continue the past activities of gap creation (i.e. tree removal), regular burning and grazing exclusion.

Broader implications

The above case study clearly demonstrates the dramatic impact of European management practices on grassy remnants on the lowland Gippsland Plain. It is difficult to determine the extent or magnitude of ecological segregation in other regions, as similar surveys have not been undertaken elsewhere. However, from personal observations and discussions with other botanists, I believe that these patterns will be found in many regions, from the southern tablelands of NSW to the northern and western plains of Victoria. Unfortunately, much of the evidence for this claim is anecdotal. However, grassy forest remnants in Gippsland have a similar composition to many woodlands dominated by River Red Gum *Eucalyptus camaldulensis*, Yellow Box *E. melliodora* and Yellow Gum *E. leucoxylon* throughout Victoria, and the land management practices that occur in Gippsland (i.e. of grazing some sites and burning others) occur throughout the state.

Site-specific examples of ecological segregation are known from western Victoria, e.g. *Themeda* grassland on the Melbourne - Ararat rail-line south of Mt Langi Ghiran *versus* River Red Gum and Yellow Box woodland in the adjacent State Park (Lunt, *pers. observ.*); central Victoria, e.g. *Themeda* grassland on the Woodend racecourse *versus* nearby Narrow-leaf Peppermint forest (Lunt, *pers. observ.*), and *Themeda* grasslands on rail-lines in the Clunes - Maryborough area *versus* nearby remnant Grey Box woodlands (N. Scarlett, *pers. comm.*, September 1992); the northern plains, e.g. *Themeda* grassland in Mitiamo cemetery *versus* woodlands in Terrick Terrick Park (Morcom 1990); and north-east Victoria, e.g. rail-line remnants containing *Diuris cuneata*, *versus* nearby open-forests (Johnson 1992). These and other known examples include grassy forests and woodlands dominated by River Red Gum *E. camaldulensis*, Yellow Box *E. melliodora*, Grey Box *E. microcarpa*, Long-leaved Box *E. goniocalyx*, Narrow-leaf Peppermint *E. radiata*, Candlebark *E. rubida*, and Snow Gum *E. pauciflora*. Assuming that such patterns will one day be properly documented in many grassy forests and woodlands throughout Victoria, the following framework can be developed:

1. Throughout Victoria, there are no unaltered remnants of the 'original' grassy forests and woodlands. Even the most intact remnants have changed dramatically, and many species have disappeared or been grossly depleted, while others have increased in abundance. Few people would debate this claim, since the ubiquitous utilisation of grassy forest and woodland remnants for timber production and grazing has caused significant changes in tree density and plant composition.

2. In most regions, small remnants on roadsides, rail-lines, cemeteries and racecourses are the only places where many of the original grassy forest and woodland species survive (Frood 1985; Stuwe 1986; Scarlett and Parsons 1982, 1992). Most of these remnants and many of these species are now threatened with extinction.

3. Because there are many 'big' grassy forest and woodland remnants throughout the state, many observers have unconsciously assumed that these large remnants are unchanged, intact remnants of the 'original' ecosystem. They have therefore invoked a lower status for the rail-line and cemetery remnants, that are described as 'disclimax' communities or unnatural 'artefacts' of doubtful conservation significance.

The interpretation in number 3 above is too simplistic and, at least in Gippsland, is factually wrong. The Gippsland rail-line remnants are no more a disclimax or an artefact than are the 'big' grassy forest remnants; both communities contain only a portion of the species that occurred in the original grassy forest and woodland ecosystem. The original grassy forests or woodlands of every region presumably contained the species that now survive in the forest and woodland remnants plus the species in the rail-lines and cemeteries.

Whether that species is *Caesia calliantha* in Gippsland, *Diuris punctata* or *Podolepis jaceoides* in any grassland and woodland region of Victoria, or any of many other threatened species (see Scarlett and Parsons 1982), for one reason or another, these species have all been dramatically depleted, or completely eradicated, from most grassy forest and woodland remnants. They have survived in the tiny rail-line and cemetery sites owing to the unique management of those sites; tree removal, no grazing and regular burning. The rail-line remnants, and their attendant management regimes, are no more 'unnatural' than the nearby forest or woodland patches. They are just considerably rarer.

Rare species?

Species without wind dispersed seeds that occur in many small and isolated rail-line and cemetery remnants could not have been rare originally. Instead, they must have been common and widespread, and probably occurred in many of the sites that now support remnant grassy forests and woodlands, even though there are no records from those sites. If a species was rare in a region prior to European settlement, then the probability that a number of populations would occur on the narrow strip of land that was later to became a rail-line is exceedingly low (Fig. 3a). Only those species that were originally abundant in the region are likely to be repeatedly found in rail-line remnants (Fig. 3d).

Many species have probably increased in abundance within individual rail-line remnants owing to favourable conditions for regeneration (e.g. regular burning), and some species with wind-blown seeds may have dispersed along the rail-line between

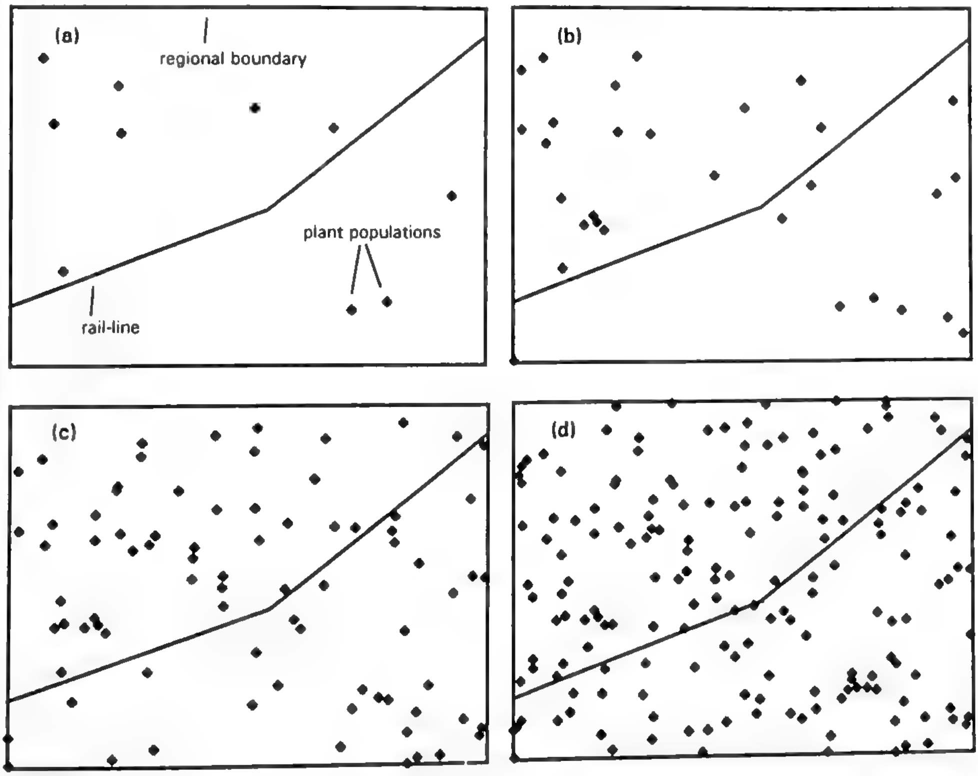

Fig. 3. Pictorial example of randomly located plant populations in a hypothetical region at the time of European settlement. The region was later to be bisected by a rail-line. If plants were originally rare in the region, then the probability that populations would repeatedly occur on the narrow band of land which was later to become a rail-line is exceedingly low (Fig. 3a). As plant density increases (Figs 3b-d), the probability of numerous populations occurring on the rail-line increases accordingly. Consequently, any species which is repeatedly found on rail-line remnants, and which does not have wind-dispersed seeds, must have been common in the region prior to settlement. This illustration assumes that the entire rail-line supports remnant vegetation. In reality, over 90% of most rail-lines now support exotic vegetation in which the likelihood of finding many native species is low, regardless of their initial density in the region. Consequently, the original densities of species which are repeatedly found in numerous small remnants on rail-lines must have been considerably greater again.

nearby remnants. However, the majority of the rail-line flora is unlikely to have migrated along the line to fill previously unoccupied sites. Most species are small and have seeds that are not distributed over long distances in the wind. The rate of migration without wind dispersal is probably extremely slow. For instance, *Caesia* seeds are about the size of a mustard seed, with no adaptations for wind dispersal. Most plants are less than 30 cm tall, and most seeds probably fall within 50 cm of adult plants, from where they might then be transported by water across the soil surface. However, even if we assume that at least one seed in every generation travels for 2 m in the same direction as the rail-line, and that this seed always grows (in reality, mortality probably exceeds 90%), and that it takes only two years for the second plant to set seed (probably 3-5 years in the wild), and that one seed from the second plant then produces another seed which travels 2 m, and so on; even under such ideal, hypothetical conditions, it would still take 1,000 years for *Caesia* to migrate over just 1 km. Clearly, the present distribution of *Caesia,* and other species, is unlikely to be the result of large scale dispersal, as the rail-lines were only built 150 years ago. Furthermore, it seems extremely unlikely that rail-line and cemetery species could have been inadvertently introduced to all of these sites by humans, on clothing, boots or vehicles. Many cemeteries, in particular, are far isolated from rail-lines, and are not managed by rail-line workers. It is far more plausible to assume that most rail-line species must have occurred in or near existing sites when the rail-line was built last century. Species that are restricted to rail-lines and cemeteries are rare now, not because they were originally rare, but simply because they are intolerant of the typical farmland and forest and woodland management, whether that be sustained stock grazing, no burning, dense trees, weed invasions or some other associated factor.

The inevitable corollary to this argument is that, in Gippsland at least, most (if not all) of the species that are now common on rail-lines may have occurred in perhaps every large grassy forest remnant in the region, even though there are no records of some of these species from most grassy forest remnants. Conversely, the species that are now common in grassy forest remnants must once have occurred in areas that are now cemeteries and rail-lines. This seems beyond debate: from soil data; from the close proximity of some grassy forest remnants to rail-line sites and from the improbability of finding these species time after time in small rail-line remnants.

Species re-introductions

Recently I suggested that regionally rare species should be introduced into secure reserves in order to save these species from extinction in the wild, regardless of whether or not there are records of these species occurring naturally in the sites (Lunt 1992). In response, Yugovic (1992) cogently argued that whilst we shouldn't necessarily require a record of a species from the exact re-planting site, we do need to have, 'a strong and reasonable expectation that the species originally occurred on the site.' I believe that this criterion may prove to be too restrictive, and suggest that we should only require that the species once occurred in a similar *habitat* in the region. Nevertheless, if the criterion is followed it does beg the question, what evidence do we need to form a 'strong and reasonable expectation'? One of the strongest sources of evidence that is available is the frequency with which species occur in intact refugia such as rail-lines, racecourses and cemeteries.

If a species repeatedly occurs in such sites within a region, and these sites encompass a range of soil textures, then we can be confident that the species must once have been widespread and common in the region. If other grassy forest, woodland or grassland reserves occur in the same region on similar soils, then we can also be reasonably confident that the rail-line species probably once occurred in those reserves also. If one wishes to know which extra species originally occurred in our few 'big' grassland reserves, all of which were once grazed by stock (e.g. Derrimut and Laverton North reserves), then the most valuable information may be obtained, not by sampling nearby paddocks with the same management history, but by sampling other more-distant remnants with different management histories, such as rail-lines and cemeteries.

Unfortunately even if we do know that a species once occurred in a particular remnant, the species won't necessarily prosper there if it is re-introduced, as the present conditions may no longer be suitable. There is little point in re-introducing a species like Purple Donkey-orchid *Diuris punctata* to an area dominated by dense, young Red Gums or a thick grove of Prickly Moses *Acacia verticillata*, as the orchid is unlikely to grow under such conditions. Nevertheless, the species might perhaps prosper there if site conditions or management were altered, perhaps by thinning the trees and re-introducing regular burning. Conversely, examples will probably be found whereby endangered rail-line species actually grow *better* in grassy forest or woodland remnants (where they are currently absent) than in their present rail-line habitats. This scenario is likely to occur for palatable species which are poor competitors, as such species could easily be grazed out of grassy forests and woodlands, only to tenuously survive beneath dense *Themeda* on ungrazed rail-lines.

Governmental policies may provide bureaucratic impediments to the successful introduction of threatened species to secure reserves, and these impediments may be as restrictive as ecological impediments. The National Parks Division of the Victorian Department of Conservation and Natural Resources (DCNR) does not permit threatened species to be introduced to any park unless there is a prior record of the species from within the park boundaries. This, of course, is a superb policy for managing large intact parks such as Croajingolong and Errinundra National Parks, and is a refreshing antidote to the Anglophile introductions of the Acclimatisation Societies.

But the policy can also be viewed as being counter-productive for the conservation of threatened species in fragmented grasslands and grassy forests and woodlands. All remnant grassy forests and woodlands have been grazed by stock, so at best the policy can only maintain the impoverished remnants of 150 years of stock grazing. Few people collected plant lists in parks last century. Most woodland parks didn't exist until 20 years ago, and most species were probably eliminated from those sites 50 to 100 years ago. If we want to save all species in remnant ecosystems in all regions, I believe we will have to stop viewing species introductions as being intrinsically undesirable. Instead, we might acknowledge them as a means of saving many species from regional or total extinction in the wild, while perhaps simultaneously restoring an original ecological diversity to the site in question. I don't propose that every regionally threatened species has to be planted into every reserve in the region; or that this policy should be extended to reserves in other less fragmented, secure ecosystems; or that introductions should occur across the entire area of any park. Instead, small areas in particular reserves in each region could be devoted to the introduction of species which are now threatened, or perhaps even extinct (Scarlett 1993), within that region. These areas would need to include the full range of micro-habitats needed for all prospective introductions.

Fire exclusion

The rarity of many grassland and woodland species is undeniably due to habitat loss; over 99% of indigenous vegetation has been destroyed in most grassland and grassy forest and woodland regions in south-eastern Australia. However, the Gippsland data clearly demonstrate that the rarity of many species in the region is not due solely to habitat loss. Instead it is due also to the imposition of management regimes which are unsuitable for those species.

Why are so many species so rare in our larger grassy forest and woodland remnants, many of which are now protected in National or State Parks? Past stock grazing is probably the reason in many instances, and this can be tested simply by introducing plants to remnants. If the plants grow and reproduce, then the sites provide suitable habitat. But past stock grazing does not seem to be the only determining factor. For instance, the Grampians National Park has one of the largest areas of non-riverine River Red Gum and Yellow Box woodlands in a reserve in Victoria: about 10,000 ha, with another 14,000 ha in the adjacent State Forest. Five populations of *Diuris punctata* are known from the park. In 1991, no plants were recorded at four of these populations, and there were only five plants at the fifth (D. Venn, September 1992, *pers. comm.* to G. Earl). There is nothing obviously distinctive about the five spots where the orchids survive, and large areas of seemingly suitable, unoccupied habitat exist. The species appears to be extremely rare in what could be (and perhaps once was) a large area of eminently suitable habitat. In Gippsland, *Diuris punctata* is abundant in many intact remnants on regularly burnt rail-lines, even though it is absent from nearly all nearby grassy forest remnants.

Perhaps a major reason that species like *Diuris punctata* are now so rare in secure, reserved, remnant grassy forests and woodlands is because hardly any grassy forests and woodlands in south-eastern Australia are regularly burnt: most are virtually never burnt (Victorian Government 1983). Fuel loads in grassy forests and woodlands are either naturally low or are reduced by grazing. Our best grassy forest and woodland remnants are essentially 'unburnt, grazing ecosystems', grazed by stock, kangaroos or rabbits. By contrast, most of our best grassland remnants are 'burning ecosystems' without any grazing. Some National Park management plans specifically forbid burning in Red Gum woodlands because of the 'fire sensitivity of the red gums' (e.g. Department of Conservation and Environment 1990). Ground fires can kill Red Gum saplings and promote the formation of gum veins in mature trees, which reduces their timber value (Dexter 1978; Robertson 1985; Meredith 1988), but ground fires will not kill large trees (Robertson 1985). Prior to European settlement, lowland grassy forests and woodlands were frequently burnt by Aborigines and lightning strikes (Nicholson 1981), and Robertson (1985) noted that frequent burning can be a valuable tool for preventing dense regeneration of Red Gums, thereby maintaining an open woodland structure.

Across Victoria, management of grassy forests and woodlands has fallen into two schools (exemplified by the Gippsland scene): 'ungrazed burning ecosystems' (in the few rail-line and roadside remnants that survive) and 'unburnt grazing ecosystems' (most of the larger reserves). As a consequence, our grassy forest and woodland flora has been partially segregated into two groups: those species that are best represented on rail-lines and cemeteries, and those species that are common in secure reserves. I suggest that, as a long-term aim, if we want to save all of the species in grassy forest and woodland regions, we might consider re-integrating these two floras, and one means of doing that may be to re-integrate the major processes of burning and grazing, so that some parts of our big, intact reserves are regularly burnt and grazed (by kangaroos, not stock).

I must emphasise that I am *not* proposing that all of our grassy forests and woodlands be regularly burnt. The ideas presented in this paper are intended to encourage readers to compare the composition of remnants with different management histories, and to seriously question current management regimes. I suggest that if we want to save all of the species in remnant grassy forests and woodlands, we simply have no choice but to adopt a more flexible approach to reserve management and to species and ecosystem conservation.

Acknowledgments

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conversations with Neville Scarlett, the mainstay of grassland ecology in Victoria for the past 20 years.

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A Trip to the Victorian Alps

R.J. Fletcher[1]

An article, in the form of a paper read to The Field Naturalists Club of Victoria on the 10th July 1899, appeared under this title (and printed in *The Victorian Naturalist* **16**, 1899). The paper was read by Charles French Jnr., close friend and colleague of Charles Walter. Charles Walter was born in Germany in 1831 and migrated to Australia when he was about 25 years old. Soon after his arrival he began collecting seeds of native plants to send home to his sister. It was through this activity that he came under the notice of the then Dr Mueller, who sent him off on collecting trips in various parts of Victoria, and honoured him by naming *Prostanthera walteri*, especially for his work in East Gippsland. Walter also made several excursions to the high country and made extensive collections which were in part purchased by Mueller. It was on one of these trips that he reported in some detail as mentioned above. The journey was made in two sections. The first to the Mt. Hotham area and the second to Mt. Buffalo (Fig. 1). Considering the modes of transport, he covered an astonishing amount of territory. Train and horse-drawn carriage were used for longer journeys, but at the age of 68, when he made this trip, he was still walking considerable distances. For instance the return trip from Harrietville to Mt. St. Bernard and Mt. Hotham was all done on foot. At the May meeting of the FNCV following this January 1899 excursion, he exhibited about 100 specimens, some half of which were named in his presentation. For the Harrietville/Mt. St. Bernard/Mt. Hotham section, those named are listed in **Table 1** (with current names following an equals symbol).

However, as stated, this is not a complete list of Walter's collection. In a recent (January 1995) retracing of his steps the following additional species were observed **(Table 2)**.

In contrast to Walter's hike up the mountain, this 1995 trip was done in air-conditioned comfort on a bitumen road, but stopping regularly to look at things. On arrival at Mt. St. Bernard there was no welcoming. Hospice as in Charles Walter's day, this having been destroyed in the 1939 bushfires. It had stood since 1863, being

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Table 1. Some of the specimens exhibited by Charles Walter at the May 1899 FNCV Meeting.

Acacia alpina	Alpine Wattle
A. penninervis	Hickory Wattle
Aciphylla glacialis	Snow Aciphyll
Aster celmisia= Celmisia spp.	Silver Daisy
A. exul (sic)= *Olearia frostii*	Bogong Daisy
Boronia algida	Alpine Boronia
Eriostemon correifolius= Asterolasia asteriscophora	Lemon Star-bush
E. myoporoides	Long-leaf Wax flower
Eucalyptus gunnii#? E. glaucescens	Tingiringi Gum
E. pauciflora	Snow Gum
Gaultiera (sic) *hispida= Gaultheria appressa*	Waxberry
Goodenia hederacea var. cordifolia= var. *alpestris*	Ivy Goodenia
Grevillea victoriae	Royal Grevillea
Helichrysum lucidum= Bracteantha bracteata	Golden Everlasting
H. rosmarinifolium= Ozothamnus rosmarinifolius	Rosemary Everlasting
H. stirlingii= Ozothamnus stirlingii	Ovens Everlasting
Helipterum anthemoides= Rhodanthe anthemoides	Chamomile Sunray
H. incanum var. *auriceps= L.albicans* ssp. *albicans*	Yellow Sunray
H. incanum= Leucochrysum albicans	Hoary Sunray
Kunzea muelleri= Kunzea ericifolia	Yellow Kunzea
Leotopodium catipes= Ewartia nubigena	Silver Ewartia
Lomaria alpina= Blechnum penna-marina	Alpine Water-fern
Oxylobium alpestre	Mountain Shaggy -pea
Persoonia chamoepeuce (sic)= *P. chamaepeuce*	Dwarf Geebung
P. confertiflora	Cluster-flower Geebung
Richea gunnii= Richea continentis	Candle Heath
Scleranthus biflorus	Twin-flower Knawel
Stackhousia pulvinaris	Alpine Stachousia
Westringiacuneata= Prostanthera cuneata	Alpine Mint-bush

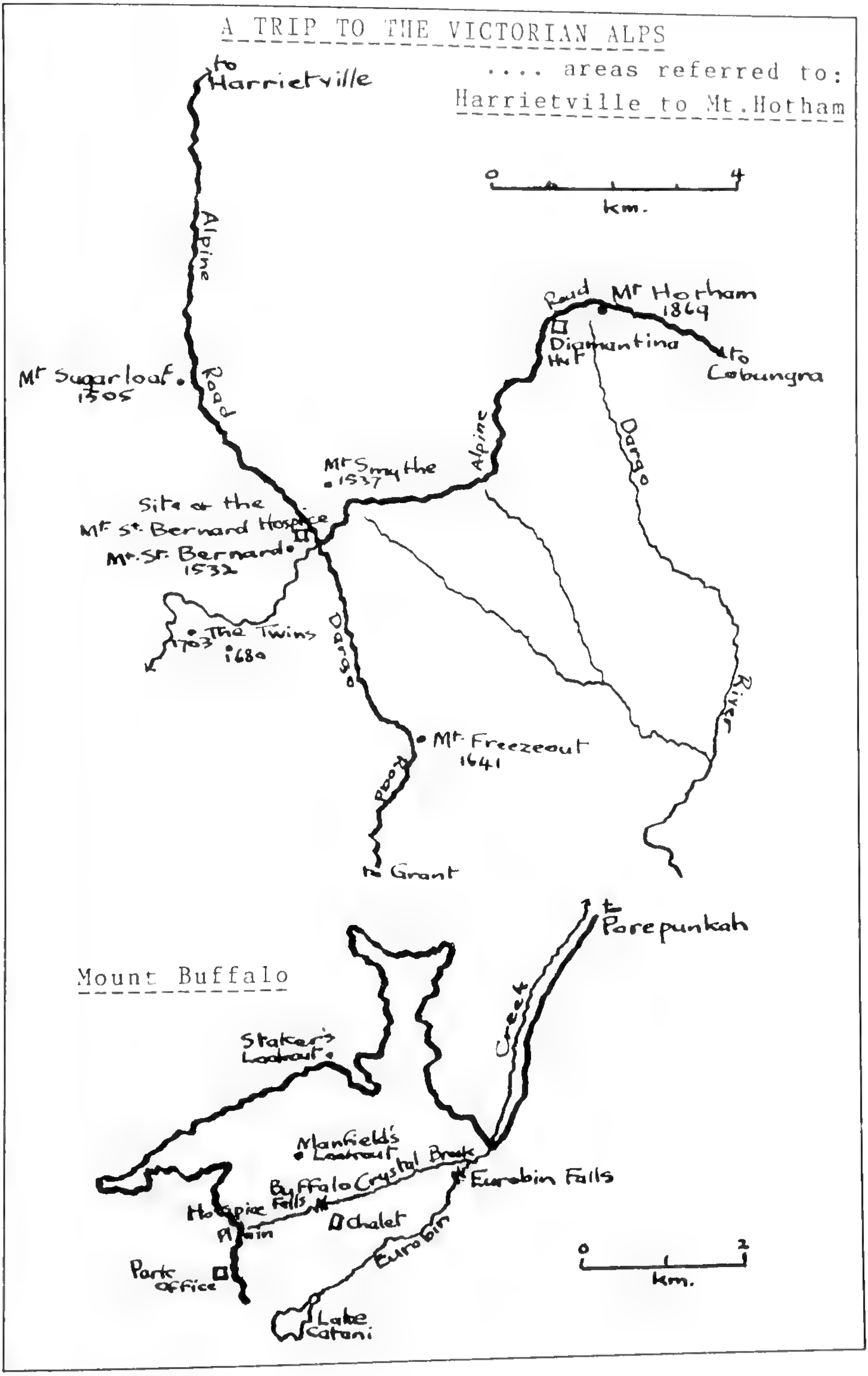

Fig. 1. Maps showing locations

Table 2. Some of the plants observed on the January 1995 trip.
* indicates exotic species. + indicates flowering.

Acacia dealbata	Silver Wattle
Arthropodium milleflorum	Pale Vanilla-lily+
Blechnum nudum	Fishbone Water-fern
Cassinia longifolia	Shiny Cassinia+
Coprosma hirtella	Rough Coprosma
Daviesia latifolia	Hop Bitter-pea
D. ulicifolia	Gorse Bitter-pea
Derwentia derwentiana	Derwent Speedwell+
Dianella tasmanica	Tasman Flax-lily
Dipodium roseum	Hyacinth Orchid+
*Echium plantagineum**	Patersons Curse+
Eucalyptus delegatensis	Alpine Ash
E. rubida	Candlebark
E. viminalis	Manna Gum
Exocarpus cupressiformis	Cherry Ballart
Kunzea ericoides	Burgan+
Lomatia fraseri	Tree Lomatia+
Oreomyrrhis eriopoda	Australian Carraway
Ozothamnus secundiflorus	Cascade Everlasting+
O. stirlingii	Ovens Everlasting+
Platylobium formosum	Handsome Flat-pea
Polystichum proliferum	Mother Shield-fern
Pomaderris aspera	Hazel Pomaderris
Ranunculus lappaceus	Australian Buttercup+
Stellaria pungens	Prickly Starwort+
Stylidium graminifolium	Trigger Plant+
Wahlenbergia gloriosa	Royal Bluebell+
W. gracilenta	Bluebell+

established to serve travellers between the Grant Diggings and the Ovens Valley. For our trip, a camp was set up between Mt. St. Bernard and The Twins just off the track. There are still signs of the old track that Walter would have walked, but the current tracks have less steep grades. On the morning following his arrival, Walter walked up to Mt. Hotham. Once again signs of the old road are still visible, but we used the bitumen and a vehicle, stopping regularly to add to the plant list. Walter remarked that 'it would be tiring if I enumerated all the different species I could have collected...the grassy slopes appeared in many places like a carpet dotted with flowers of various colours..'. However tiring, here is a list (**Table 3**) of the plants seen between Mt. St. Bernard and Mt. Hotham which do not appear on Walter's printed list. It shows that the carpet is still 'dotted with flowers', but of course, a large expanse is now covered by ski lodges, ski-tows and lifts, parking areas and other ancillary structures. On his way back down the track, Walter noted new accommodation at the Diamantina Springs, where refreshments were available. This is now the site of a refuge hut, but it was disappointing to see that vandals have been at work and that the emergency telephone has been pulled from the wall. One wonders why people in such places commit such acts. The 'bridle track' from Diamantina Springs referred to in Charles Walter's article is now the walking track to Mt. Feathertop, and nearby is the hut of the Mildura Ski Club. On the day after he arrived, Walter walked over The Twins in the morning and in the afternoon visited Mt. Smythe. From below here he stated that he 'followed the source of the Dargo River downwards, returning by the Grant or Crooked River Road'. Being about the same age as he was at the time, one can only admire his energy! The country is very steep with a very dense understorey of *Tasmannia xerophyla*, *Oxylobium alpestre* and *Acacia alpina* beneath closely spaced *Eucalyptus pauciflora*. No attempt was made to emulate

Table 3. Plants seen in 1995, in addition to those listed by Walter.
\+ indicating in flower. * indicates exotic species.

Asperula pusilla	Alpine Woodruff+
Brachyscome angustifolia	Daisy+
B. rigidula	*Leafy Daisy+*
Bracteantha subundulata	Orange Everlasting+
Craspedia spp.	Billy Buttons+
Drosera arcturi	Alpine Sundew+
Epilobium sp.	Willow Herb +
Euphrasia collina	Glacial Eyebright+
Hovea montana	Alpine Hovea
Leptospermum myrtifolium	Myrtle Tea-tree
Leucopogon gelidus	Beard Heath
Microseris lan ceolata	Yam Daisy+
Olearia frostii	Bogong Daisy +
Orites lancifolia	Alpine Orites +
Pimelea axiflora var. *alpina*	Bootlace Bush
Polyscias sambucifolia	Elderberry Panax
Prasophyllum alpinum	Alpine Leek-orchid +
Prasophyllum suttonii	Mauve Leek-orchid +
Rubus parvifolius	Small-leaf Bramble +
Senecio spp.	Groundsel +
Taraxacum sp.*	Dandelion +
Tasmannia xerophyla	Alpine Pepper
Trachymene humilis	Alpine Trachymene+
Viola betonicifolia	Showy Violet+

Table 4. Some plants mentioned in Walter's paper.

Acacia penninervis	Hickory Wattle
Baeckea crenatifolia	Fern-leaf Baeckea
Bauera rubioides	Wiry Bauera
Gaulteria (sic) *hispida* = *Gaultheria appressa*	Waxberry
Grevillea parviflora	Small-flowered Grevillea
Kunzea corifolia (sic) = *Kunzea ericifolia*	Yellow Kunzea
Leptospermum spp.	Tea Tree
Logania floribunda = *Logania albiflora*	Narrow-leaf Logania
Micrantheum hexandrum	Box Micrantheum
Mirbelia oxylobioides	Mountain Mirbelia
Pultenaea mollis	Bush Pea
Pultenaea. spp.	Bush Peas
Trachymene billardieri = *Platysace lanceolata*	Shrubby Platysace

Walter at this point. It would appear from Vicmap 8323-N that the Dargo River begins below Mt. Hotham and what Charles Walter referred to is a tributary. On the other hand the RACV map of the area shows the tributary below Mt. Smythe as the Dargo River. One presumes that the Vicmap is correct. On the following day, Walter walked back to Harrietville, collecting specimens that he had missed two days earlier because of 'two severe thunderstorms, hail and steady rain, which made the roads very muddy'. Because of this it had taken him seven hours to make the trip up. On the way back it took only six! Not really bad for someone carrying his luggage, including press and specimens. It's only 20 kilometres! One similarity between the two excursions was a day of foul weather. Following the trip to Mt. Hotham, we also had a violent thunderstorm, which passed and settled down to steady rain for the next 24 hours. While Walter walked back to Harrietville to take a coach to Bright and then a train to Porepunkah, we returne d to Porepunkah by way of The Twins Track, Selwyn Creek Road, and the Buckland Valley Road. Walter had used as his base here Manfield's Buffalo Falls Temperance Hotel, about 6.5 km from Porepunkah, from where he had walked 'arriving in good time for breakfast' after having taken the 5 a.m. train from Bright. We camped at the Buffalo Caravan Park at the junction of the Ovens and Buckland Rivers. The building known as Manfield's Temperance Hotel still stands, but not for long. For many years it has been called Buffalo Lodge and has served a variety of purposes. It is in a sorry state of disrepair and the present owners are about to demolish it and rebuild, but with a sense of history in mind. We did the same as Charles Walter and 'botanised along the Eurobin Creek' as far as the Eurobin Falls for the rest of the day. Among the plants he collected, the following are listed in **Table 4.**

Walter complained that there was no proper track up to the Falls , but there is one now, within the National Park, and for the use of which there is an entry fee of $6. Additonal plants found in 1995 are listed in **Table 5**. This table list indicates that January is too late for the peak of the flowering season.

There had been recent heavy rains so the Falls were in good shape, as were the Buffalo Falls, of which there is a good view from below the Eurobin Falls. From Charles Walter's description of the track he took next day to the Plateau, it may well have followed fairly well along the existing winding road. Certainly one of the early promoters of the area, in 1887, was a W.A. Staker, and there is a Staker's Lookout on the track. Walter walked up here with one of the Manfield sons. We drove up in comfort, stopping on many occasions. He would have walked from what is now the Hospice Plain along 'a small stream' which is Crystal Brook, and which provides the water for the Buffalo Falls not far away. Nearby is a carpark from which there is a circuit leading to various points of interest around the Gorge. Walter's plant list for this area included those in **Table 6.** To Walter's list in Table 6 may be added the following plants from January 1995 (**Table 7**).

Apart from the botanising, the rewards for these walks include the fantastic views from the Gorge area, and of course from other places all over the Buffalo Plateau. The purpose of this part of the trip was to follow as far as possible in the footsteps of Charles Walter, so other parts of the area had to be left for another time.

It is a great pity that the collection Walter made and left with the Manfield family no longer exists. The specimens he collected for Mueller are no doubt safely housed in the National Herbarium at Melbourne. Walter had also donated a pressed collection to the

Table 5. 1995 additions to Walter's Table 4.
+ indicating in flower.

Acacia dallachiana	Catkin Wattle
A. kettlewelliae	Buffalo Wattle
A. melanoxylon	Blackwood
A. obliquinervia	Mountain Hickory Wattle
A. phlebophylla	Buffalo Sallow Wattle
Billardiera scandens	Apple Berry
Bursaria spinosa	Sweet Bursaria +
Calochlaena dubia	Ground Frern
Calytrix tetragona	Fringe Myrtle
Carex appressa	Tall Sedge +
Cassinia aculeata	Dogwood +
C. longifolia	Shiny Cassinia +
Daviesia latifolia	Hop Bitter -pea
Dianella tasmanica	Tasman Flax-lily
Dicksonia antarctica	Soft Tree-fern
Dodonaea viscosa	Wedge-leaf Hopbush
Eucalyptus mannifera	Brittle Gum
E. radiata	Narrow-leaf Peppermint
Gleichenia dicarpa	Pouched Coral-fern
Grevillea alpina	Cat's Claws
G. victoriae	Royal Grevillea
Hedycarya angustifolia	Austral Mulberry
Hymenanthera dentata	Tree Violet
Kunzea ericoides	Burgan+
K. parvifolia	Violet Kunzea
Lomandra longifolia	Mat Rush +
Lomatia ilicifolia	Holly Lomatia
Mentha laxiflora	Forest Mint
Pandorea pandorana	Wonga Vine
Parsonsia brownii	Twining Silkpod
Platylobium formosum	Handsome Flat-pea
Pomaderris sp.	Pomaderris
Rubus parvifolius	Small-leaf Bramble+
Spyridium parvifolium	Dusty Miller
Todea barbara	Austral King-fern

St. Bernard Hospice, but that piece of history would also have disappeared.

After enjoying the hospitality of the Manfield Buffalo Falls Temperance Hotel, Walter took the train back to Melbourne, having accomplished all he had done in the space of a week. Rumour has it that the hop-beer served at the Temperance Hotel rather stretched the meaning of the word 'temperance', but we'll never know.

Table 6. Walter's plant list.

Epacris mucronulata ? *Epacris microphylla*	Coral Heath
Kunzea muelleri = *Kunzea ericifolia*	Yellow Kunzea
Podolepis longipedata = *Podolepis robusta*	Alpine Podolepis
Ranunculus anemoneus #?	erroneus record (Willis, Vol. II, 156)
Ranunculus gunnianus	Alpine Buttercup
R. lappaceus	Australian Buttercup
Richea gunnii = *Richea continentis*	Candle Heath

Table 7. 1995 additions to Walter's Table 6.
+ indicating in flower.

Acacia obliquinervia	Mountain Hickory Wattle
A. phlebophylla	Buffalo Sallow Wattle
Arthropodium milleflorum	Pale Vanilla-lily +
Bursaria spinosa	Sweet Bursaria +
Daviesia ulicifolia	Gorse Bitter-pea
Dianella tasmanica	Tasman Flax-lily +
Eucalyptus delegatensis	Alpine Ash +
E. mitchelliana	Buffalo Sallee
E. pauciflora	Snow Gum
Goodenia hederacea	Ivy Goodenia +
Kunzea parvifolia	Violet Kunzea
Leptospermum micromyrtus	Button Tea-tree+
Leucochrysum albicans	Hoary Sunray +
Lomandra longifolia	Mat Rush
Oxylobium alpestre	Mountain Shaggy-pea +
Pimelea humilis	Dwarf Rice-flower +
Platysace lanceolata	Shrubby Platysace +
Polyscias sambucifolia	Elderberry Panax
Polystichum proliferum	Mother Shield-fern
Stylidium graminifolium	Trigger Plant +
Tasmannia lanceolata	Mountain Pepper

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Mountain Ducks *Tadorna tadornoides* - Tragedy of Instinct

One bright morning, in late spring, the lady at the farm where I was staying, in far East Gippsland (on the Numeralla side of the Orbost Flats), drew the attention of her husband and myself to a pair of Mountain Ducks and their numerous brood, which she had had under observation for about an hour.

The birds were on the opposite side of the gully from the house and under easy observation from the kitchen window. They were on their way from the adjoining bush, where the chicks had been hatched, to the wetlands on the flats below. They had come up against a netted fence, not one to prevent them from going down to the flats but one preventing them from going further along the cliff tops which happened to be the particular place they had in mind (or whatever it is that actuates such birds).

The adult birds were unable to get through but the amazing thing was that the netting fence offered no obstruction whatever to the chicks who ran freely back and forth through it, seeming to float like a single splash of brilliant colour against the deep green of the pasture, while their parents moved stolidly back and forth looking for a way through, all the time calling loudly to their chicks.

At our approach the adult quickly took to the air and landed on the opposite side of the fence and headed, not down the cliff face to the water below, but along to the next fence which barred their way and the same performance again took place. Again we moved and the adults flew over but just at that moment a hawk appeared on the scene intent upon some of those chicks for its breakfast. Immediatedly the drake was in the air hurling himself at the hawk. While the hawk had the speed and turning ability, the drake certainly had the weight. We assisted by shouting and whirling our hats into the air. Altogether this was too much for the hawk and it just as quickly disappeared.

All this time the duck was hurrying the chicks ever closer to the safety of the cliff face with its trees and shrubs which offered easy access to the lagoons and connecting channels below.

The only other fence was now a long way along the cliff face, where the road snaked up at an angle to the higher ground above. So we left them, well satisfied with our good deed for the day.

The next afternoon I had occasion to travel up that road and there in the paddock was the drake with one chick, both running away from the fence at my approach. I soon found the duck, minus its head and much of its breast, a typical victim of a hungry fox.

I put the drake and its solitary chick across the two road fences where the chick promptly disappeared down an underground water course but as the drake landed nearby he would soon call it out. I had to leave them again, hoping the cleared gully ahead would divert them, at last, to the safety of the water.

G.A. Crichton

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FNCV New Home in Blackburn

Work is proceeding with internal changes to 1 Gardenia Street, Blackburn. The library has now been partitioned off and the kitchen and laboratory area is taking shape. The library is expected to be installed completely by mid December and we are on track to have everything completed by the New Year.

From January 1996 Club meetings and activities will take place in the hall.

You are welcome to come and see the progress on any Wednesday or Thursday.

Pond Hunting

D.E. McInnes[1]

Most people look at a lake or pond and just see a sheet of water and think, "I suppose there are some fish there and they eat the things in the water", and that is all, but to the POND HUNTER there is another world of life below the surface of the water - both plant and animal life as well as other remarkable forms of life that are actually plants but look like very active animals swimming around.

The larger forms such as fish, crayfish and yabbies we will leave to the fishermen.

There is the life we can see with the naked eye - the larger forms of algae, and the many aquatic insects and their various larvae, even aquatic spiders as well as a variety of snails.

Next is that wonderful world of microscopic aquatic life. Many can be seen with a hand lens but most need to be examined under a microscope which reveals a third world of living creatures all rushing around to 'get a bite to eat'.

To obtain samples, different methods are used:

First - Aquatic insects and their larvae. To catch these you need a shallow net 20 to 30 cm wide (made of old, fine mesh curtain material) with a long handle. It needs to be strong so that you can draw it along under the surface among the weeds in the shallow water. Tip the contents of the net, usually a mix of broken weed, onto a white plastic sheet and examine the catch. Among the weed will be various insects or larvae, perhaps a brilliant-colored red or blue water mite that will race around, some aquatic snails, tadpoles and small fish.

Now lift them out with a plastic spoon, not tweezers, and place them into a white saucer or shallow dish filled with pond water. Then you can examine them carefully with a hand lens and put them into jars to take home. Be careful to place each kind in a separate jar because some will eat others.

At home, place into shallow containers, white margarine containers are ideal. White ice-cream containers cut down to 3 cm deep with scissors also make good observation dishes.

Second - For the forms of life that require at least a good hand lens to see, or are so small that a microscope is needed to see them properly, for these we require a different net to catch them, as well as a special trough for a first examination with your hand lens.

This net needs to be 15 cm wide sloping down as a cone to fit a glass jar about 4 cm wide. The lid of the jar has holes bored into it, and the net is attached to the lid. The jar can be 6 to 8 cm long. The top of the net is sewn to a circle of strong wire which is attached to a good strong handle a metre or more long. The material of the net must be a very fine mesh. Examine the mesh with the hand lens or with 100 magnification under the microscope, this will give you some idea of what size catch will slip through your net.

A glass trough is needed to examine the catch with the hand lens. To make the trough you need two pieces of thin window glass cut into 8 cm square and some thick (5 mm or more) plastic, 1 cm wide. Stick the glass and plastic together with Selley's glass sealant.

One more handy item is a plastic tea-strainer. This allows you to strain off the larger forms such as water boatmen when putting your catch into the containers to take home.

The pond life can be considered as three sections:

1) The free swimmers - those near the edge of the pond among the weeds will be different from those in the clear water well away from the edge.

2) The forms attached to weeds - many of which are the most interesting animals to observe under the microscope.

3) The life that lives just on top of the mud surface.

Now let us catch the free swimmers. Sweep your net through the water near the surface and also deeper down with just

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enough speed to strain the water through the net several times then lift it up slowly allowing the forms to sink into the jar. Unscrew the jar from the cover and pour the contents into the trough. Now you can examine the catch with your hand lens. If you want to retain it, strain through the tea-strainer to remove unwanted large forms and place into your container to take home. Make other sweeps near the edge and also out in the deeper water. Remember to number all your containers and label with the date and location. Also make notes in a field notebook. Use a waterproof marker (e.g. lead pencil).

The attached forms cannot be caught with the net, it is necessary to pick many samples of weed and place them in the trough and carefully examine to see if there is anything of interest. If a good find is seen on a weed, place it in a separate container to avoid losing it. It is a good idea to take plenty of weed sam p les to examine at home with the microscope.

The forms that live near the mud surface can only be obtained by sucking up or scooping the top layer of mud, this results in a lot of dirty muddy water. However, just place it in a container to look at when you get home.

When you arrive home remove the covers from the containers and if possible place in a series of shallow wide dishes. Number these the same as your containers

How to look at the material when you have got it home

Place the **insect larvae** material in your observation dishes under a strong desk lamp and just watch for movement. To examine a specimen lift it out with a plastic spoon that has small holes bored in it and place it in the trough filled with clear pond water and examine with the hand lens or place in a small petri dish and examine with a low power microscope (15x to 20x).

Now to examine the **free swimmers**. Place contents of jar in an 8 cm petri dish (make your own petri dishes with glass squares 2 mm thick if possible, and circles cut from plastic down-pipe, stick with Selley's glass sealant). Examine with hand lens or the lowest power of the microscope. This will give you an idea of all the catch. For closer examination select a specimen with a pipette and place in a smaller petri dish.

If you want to look at, say a 'Water Flea' or a Rotifer in a single drop of water, obtain a piece of thick clear plastic about 2.5 cm by 7.5 cm. Why? Because a drop of water will remain a circular drop on the plastic but will spread flat out on glass. Place 3 small pieces of Plasticene around the postion that the drop will cover, place the drop of water, with the specimen, on the plastic and then cover with a glass cover slip or a clear plastic cover. Press down until the specimen is caught between the slide and cover (note - any thin clear plastic stuck to a glass slide will do, even just sticky tape stuck to the slide will do in a pinch). Now examine the slide under the higher powers of the microscope.

To examine the **attached forms**, place some of the weed in the trough or in a wide petri dish and check with the hand lens or under the lowest power microscope. Pick out any specimen with the tweezers, cut off excess weed and place in a small petri dish. If it projects above the water, cover with a glass cover. Examine with the higher powers of the microscope. Remember that the lower powers of magnification give the best depth of focus.

The **muddy water** collection should be put in a wide dish until the mud settles, then, with a pipette, draw off the layer just above the mud. Place this in a smaller dish and let settle. If the mud layer is opaque draw off some of the mud until open spaces are seen. Again select specimens and put in a drop of water for further examination.

Now, when you see something interesting, how will you know what it is? Well, the best book, one that covers all the things you are likely to see in a freshwater lake or pond is the one below:

Australian Freshwater Life. The Invertebrates of Australian Inland Waters - W.D. Williams. This book was reprinted in 1985 and you will probably have to go to your local library to obtain a copy. The FNCV library has a copy members can borrow.

A book that is available and is a must for any pond hunter with any interest in rotifers or 'water fleas' is:

A Guide to Identification of Rotifers, Cladocerans and Copepods from Australian Inland Waters - R.J. Shiel.

This book has over 500 illustrations of rotifers and explains in detail methods of catching, preservation and mounting specimens. There is also a pictorial reference to key out the species of 'Water Fleas', Cladocerans and Copepods. Price is $33.00 (posted). Obtainable from The Murray-Darling Freshwater Research Centre, PO. Box 921 Albury, N.S.W.2640.

Another excellent book to look up in the library is

The Natural History of Aquatic Insects. (1903) - Prof. L.C. Miall. It has nearly 400 pages of the interesting life stories of the aquatic insects you will catch in your net.

Some overseas books to obtain from your library.

Freshwater Biology - Ward and Whipple.

A Guide to the study of Fresh-water Biology - J.G. Needham and P.R. Needham.

The FNCV Microscopical Group is willing to help anyone with pond hunting or the use of a microscope. Your contact is Ray Power, telephone (03) 9717 3511.

From our Naturalist in Residence, Cecily Falkingham

White-winged Choughs *Corcorax melanorhamphos* and Bird Behaviour

From the early days of my childhood when the Gould League of Bird Lovers (Gould League of Victoria Inc.) visited my Primary school, I was hooked on birds. I enthusiastically signed the pledge, promising to protect native birds and not to collect their eggs.

I must have been one of thousands of children whose first introduction to birds was through the Gould League. Subsequently, for many years, the League has embraced all aspects of natural history.

The great and late Crosbie Morrison with his 6.00-6.15 p.m. 3DB Sunday broadcasts fanned the flame of my enthusiasm as I listened to that wonderful voice of quiet authority.

Then followed TAFE and Council of Adult Education courses and eventually, two decades ago, becoming a member of The Bird Observers Club.

For most nature lovers or naturalists, birds are only one small, but fascinating part, of the whole picture. My curiosity about bird behaviour is the driving force behind an interest in birds. It has never been important to me how many bird species I see in one day (I would fail dismally as a twitcher). What interests me is the quality of the observation, what I have learned about the species and what the bird was doing at the time.

My first experience with a flock of White-winged Choughs *Corcorax melanorhamphos* was within cycling or walking distance from my home. In January 1981, I discovered an enormous mud nest, 20 cm wide, overflowing with two fat, lively chicks. I had previously observed the nest in November 1980. The area was open Manna Gum bushland beside the Mullum Mullum Creek. A place where Yellow-tailed Black Cockatoos *Calyptorhynchus funereus* looped lazily through the trees in winter and where Little Falcons (Australian Hobby) *Falco longipennis* nested in the old disused Ravens nests.

The inevitable soon happened and houses pressed further down onto the edge of this have, the owners bringing with them their domestic pets. In less than one decade the Chough no longer entertains me with its sombre wailing and enchanting whistles. We had, and still have, a high population of foxes which also played a part in their demise.

In the past twenty years I have observed White-winged Choughs at Rushworth Forest, Bendigo Whipstick Forest, Gembrook State Forest, Inglewood, Little Desert National Park, Pink Lakes State Park, Hattah-Kulkyne National Park, Chiltern State Park, Macedon Ranges (Mt Teneriffe area), Wychitella Forest, Warby Ranges National Park, Warrandyte State Park, and, closer to home, Currawong Bush Park in Templestowe. Their preferred habitat is open woodland, Mallee of south-eastern Australian and new crops and pastures.

White-winged Choughs are usually heard long before they are seen, their miaowing, wailing, whistling, mournful call being like no other bird. The birds are usually sighted when disturbed, flapping lazily through the middle canopy. A flock, unaware of your presence, is usually found feeding on the ground. They can be confused with Ravens until they take flight exposing the white underwing patches. Their eyes are a bright ruby-red, unlike Raven *Corvus* spp. with their *white* eyes or Pied Currawongs Strepera graculina with *yellow* eyes.

Choughs feed on invertebrates and larvae, seeds (their liking for seed does not endear them to farmers) and berries. They probe the ground vigorously with their strong, sickle-shaped beaks, flipping sticks, stones and leaf litter up to 30 cm in the air. Their stout, heavy bodies sway from side to side as they stride along on the ground on strong thick-set legs.

They control a territory of about 50 ha and are not aggressive birds, living peacefully in their large groups. Groups range between 10-30 birds in a family gathering. On rare occasions when conflict is unavoidable, the battle takes the form of whistling matches with elaborate tail and wing wagging. Displays of aggression are rare and usually end in a few minutes.

The aggressive nature of nesting Magpies and their excellent flying ability make the Choughs' life quite hectic when their territory overlaps into Magpie territory. Several times a day the Magpies will dive-bomb the Choughs and have been seen to tilt at a Chough's tail in mid-air flying battles, tipping the Chough a nd unbalancing it so that it crashes to the ground.

Choughs breed sometimes as early as June but usually between July and December, and not normally until their fifth year. Choughs have been known to live ten years. The nest can take anything from one week to several months to build if a dry spell intervenes. All the birds, apart from the very young, help build the nest and all help in incubating, brooding, nest sanitation and nestling feeding. The nest can be from 10-20 m or more high, usually in a Eucalypt species. I have observed them on forked or single horizontal branches. The nest is lined with soft material such as grass, wool or bark. Old nests are frequently used again and again and have proved to be of a solid well-built construction - when one came down attached to the branch after a storm, it remained intact. It has been recorded that cattle dung and Emu dung have been used and mixed with the mud. The fibre content makes up at least 7% of the whole.

Eggs take 19 days to hatch, and then for 25 Days the older birds in the group, male or female, tend the young. Although as many as eight or nine eggs can be laid by several females in the group in the one nest, only abut two birds on average are successfully raised to maturity. The birds have very weak flight for the first couple of days after leaving the nest and in these early days they are at most risk from predators; foxes, feral cats, roaming dogs and, to a lesser extent, the occasional shooter find them and their nests easy targets. Sometimes farmers kill Choughs in country areas because of their grain-eating habits, quite forgetting that they consume armies of insects. When insects are scarce, in winter, the birds depend on seed and berries, and, being a large bird, their food intake is quite considerable.Once the young birds have fledged and learned to travel, they leave their breeding grounds travelling and foraging for food over an area of 500-1,000 ha. As open woodland is rapidly being replaced by sheep and wheat farms, the birds are becoming less common and, as the urban sprawl reaches out even further into suitable Chough habitat, they are becoming rare in southern Victoria. Mallee scrub, the preferred habitat, and watercourses are also areas that are fast-dwindling!

One of the most exciting bird-watching activities I have experienced concerns the White-winged Choughs' behaviour. As I rounded a corner on the flats beside the Mullum Mullum Creek I accidentally walked into a flock of ground-feeding Choughs. They were intent on feeding and I was looking up, binoculars to my eyes, when we stumbled into each other. At once the group of about seven Choughs joined forces, bunched up together and with much overhead flapping of wings and snapping of bills, a screaming mass of black and then white with large red engorged eyes completed this very impressive display of aggression. It was sometime later that from Ian Rowley's book 'Bird Life' I learned that I had witnessed one of their rare displays of aggression called 'plum pudding display', so-called because of the round shape of the mass of birds and the black, white and red colours scrambled together.

Recently, whilst walking with a group, I was able to observe a Chough's nest at Warrandyte. The nest was overflowing with two large nestlings and a third youngster was being fed on the ground. A tuft of fine grey to buff feathers on the bird's crown facilitates camouflage, making the bird difficult to see in the nest and on the ground. Their head feathers resembled the colour of the nest rim. the red eye of the adult bird is not obtained until one year old. All chicks were exactly the same size and five adult birds danced attendance on them. Then one member of my group noticed a sub-adult who raised its wings and fluttered and quivered begging for food imitating the new chicks. This bird was obviously reluctant to be forced out from the number one position.

These large sedentary or locally nomadic birds of mainly peaceful disposition are a species about which we still could learn a lot more. Their complicated social structure and food requirements are being stretched to the limit with habitat loss. Ian Rowley has this to say:

> 'Choughs, rather than being an aggressive, expanding species, are a mild, slow maturing, slow breeding, weak-flying bird, ill adapted to coping with the new predators such as the fox and feral cat. Their extinction is probably only a matter of time, that may well be delayed by the abundance of grain introduced to their native environment.
>
> However, Choughs seem to be one of the few species that have taken to Pine Plantations so there may be hope for them yet as specialists feeders amongst the pine needles'.

I wonder how much closer to that prediction we are, two decades after Ian Rowley wrote those words?

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Northern Pacific Seastar

Tim O'Hara[1]

Asterias amurensis, or the Northern Pacific Seastar, is an exotic seastar that now occurs in very high numbers along the south-east coast of Tasmania. It was probably introduced via ship's ballast water in the 1980's. Each female can produce up to 19 million eggs each season and spawning occurs in early spring. The seastar's impact on native marine life appears to be considerable and it also poses a threat to aquaculture ventures. In August 1995 a single female was reputedly found off Point Cook in Port Phillip Bay.

Asterias amurensis has five elongate arms, with slightly swollen bases tapering to a pointed tip. Each arm can grow up to 20 cm in length. There are small, sharp spines scattered over the central disc and arms. Underneath the animal in the furrow that runs along each arm, there are four longitudinal rows of tube feet. Tube feet are fleshy tube-like organs with suckers at each end that enable the seastar to grasp its prey. With a hand lens or microscope you can see a single series of sharp spines running along the margin of the arm furrow. Tiny pincer-like structures called pedicellariae are densely spread over the body and spines. The colour is a mottled purple, yellow or orange. Preserved specimens lose their original colour and become uniform orange.

Some native seastars with five arms are regularly mistaken for *Asterias*. However, they can be distinguished by their blunt, round-tipped arms, their thick, rounded spines on the upper surface and their two longitudinal rows of tube feet or two longitudinal rows of spines on the margin of the arm furrow. The colour of these native seastars can be a mottled red (*Smilasterias irregularis*), black and white (*Smilasterias multipara*), or mottled red, orange and purple (*Uniophora granifera*).

If FNCV members think they have found a Northern Pacific Seastar it should be sent to an appropriate institution as soon as possible to verify the identification. The animal is not poisonous and can be dried in the sun or preserved in methylated spirits. Specimens can be sent to a local Department of Conservation and Natural Resources office or to the Museum of Victoria. It is crucial that the exact locality and date of the find is sent with the specimen.

Despite the high fecundity of this species, the most likely method of dispersion to other Australian ports remains human translocation of sea-water. This can be via ballast water, bilge water or through the transportation of live marine animals or plants. Most southern Australian ports now have some introduced species. In the long run the design of boats and ports will have to be modified to treat ballast water. In the meantime, however, all boat owners have a responsibility to avoid spreading marine pests by keeping their hulls and fishing equipment clean, and ensuring that water from one port is not released into another.

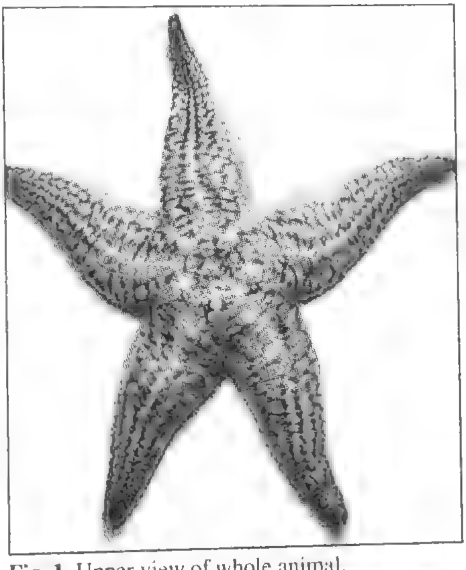

Fig. 1. Upper view of whole animal.

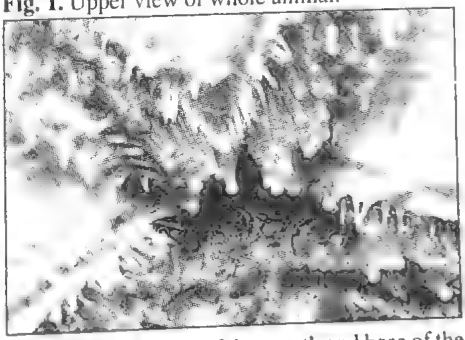

Fig 2. Detailed view of the mouth and base of the arms. *Photographs are courtesy of T. Bogue.*

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The Bush
(A Guide to the Vegetated Landscapes of Australia)
Second edition

by Ian G. Read

Publisher: *University of New South Wales Press, Sydney, 1994.*
184 pages. RRP $22.95

The alluringly simple main title of this guide invites the lover of Australia's unsettled areas to browse through its 184 pages of text and photographs, both colour and black and white. However, this is not a homage to the world of Banjo Patterson or Bob Brown, but an attempt to teach the reader how to recognise and describe the vegetative landscapes of this large and varied country.

A comprehensive, yet widely accessible, method of vegetation description has been an elusive goal for many writers in this country and elsewhere. While descriptions of plant communities and associations have been successfully produced for defined, usually relatively small areas (e.g. pre-logging surveys, and vegetation surveys of the mallee to the alps), attempts to extrapolate to large areas (states or countries) have usually foundered simply because of the scale of the task and the number of variables (plant species, soils, climates, land-use).

Ian Read's book sets out to address that problem. Following a relatively brief introduction as to why plants may be where they are, through sections on climate, soils, geology, topography, and land use by native and colonising peoples, we are introduced to the method favoured by the author to classify 'the bush'. By concentrating on structure - height and density of vegetated canopy, shrub and ground layers - similar structural formations in Australia, once recognised, can be pigeon-holed into a named formation.

The framework for Read's guide is based on the classification first presented by Specht in 1970. This valuable system has been fairly inaccessible to the general public, so 'The Bush' has done a service in bringing Specht's work into greater prominence. Specht's original matrix of 'projective foliar cover' and height of the dominant stratum to describe the 50 or so vegetation formations (e.g. closed forest, open forest, woodland, scrub, shrubland, heath etc.) is augmented by line-drawing profiles of relevant stands. To this existing classification, Read has added qualifications such as 'shrubby', 'grassy', 'layered', sometimes an environmental description 'subalpine', 'northern', 'coastal' and sometimes an indication of the dominant plant group '*Acacia*', '*Banksia*', '*Themeda*' etc. Hence, the next 100 or so pages are given over to the various permutations and combinations (I estimate 300) of these possibilities such as 'Vine-fern closed forests' (pp. 40, 41) and 'north-eastern *Acacia* shrubby and grassy tall open shrublands' (p. 106). Alternative 'common' names (such as 'warm temperate rainforests' for the first example above) are offered for some of the better known types of vegetation.

Each formation is summarised giving its distribution around the country, the most likely habitat(s), substrate(s), an indication of the 10 or so plant genera or species that are likely to be encountered, and a comment on the likely fate of the formation since white settlement (termed 'Transformations'). Following the formation descriptions are some notes of interest on the principle genera and/or families encountered in 'The Bush', and a glossary of terms used through the work.

If all of this seems to answer your needs when describing or appreciating 'the bush', then this is probably the book for you. Some caveats and quibbles, however. The coverage of eastern, northern and central Australia appears reasonably comprehensive, but Western Australia, particularly the florally rich south-west, rarely rates a mention. One gets the impression that it is the areas most familiar to the author which get the 'full treatment'. Read has preferred to use common names throughout the book (although this is an inconsistently applied preference). Most (but not all) are given their botanical binomials in the Index, but for one with some familiarity of the commonest genera in this broad country, it is a frustration to constantly refer to the index to query 'Crows Ash', 'Queensland Maple' 'Rhodes Grass' etc., and which of the multitude of Australian 'lawyer vines' is being referred to. Inevitably, with the incomplete vocabulary for common names of Australian plants, the same common name has occasionally been applied to two different species, or in the case of 'Iron- wood', three. The problem of common names is exemplified in illustrations of 2 different grasses captioned as 'Spinifex' (p. 163). The name is used for coastal *Spinifex* (the genus) and unrelated inland *Triodia* without any indication of the true identity of either. The identification of illustrated species through the book is unfortunately very patchy (many of the photographs a re however quite beautiful). Most are apparently accurately identified to at least genus, some queried. (e.g. '?brigalow', p. 64), some not attempted, and some plain wrong (e.g. '*Poa* tussock' for what is surely *Stipa stipoides*, p. 141, 'Millstream Fan Palm' *Livistona alfredi* for what is not a *Livistona*, (p. 139). *Podocarpus alpina* (p. 42) presumably refers to *P. lawrencei*. Spelling errors are unfortunately common - 'phyllum' for phylum (throughout), 'kuari' for kauri (p. 39), 'schlerophyll' for sclerophyll (p.45), *Trioda* for *Triodia* (throughout), *Erythropleum* and *Erythrophloeum* (several) for *Erythrophleum* and many others. They are perhaps nothing more than an annoyance to the pedant, but better proof-reading would have eliminated most of these. A number of comments or claims are made which sometimes surprised me, and although I'm in no position to doubt their veracity, I would have appreciated the opportunity to follow these up through a referenced source. Examples are 'heaths are home to 20 species of birds (3 must live here) and 22 species of mammals, all of which can live elsewhere' (p. 83) - the New Holland Mouse and Heath Rat might dispute this - and, that most eucalypt hybrids 'seem to result from human interference as most occur on margins of cleared land' (p. 157).

In the author's words 'to be able to put a name to something greatly assists in interpreting what is being seen while to actually discover that named 'something' is a rewarding experience in itself'. Although the sentiment in this quote is admirable, and summarises the aims of 'The Bush', its expression may seem a trifle unclear. A less than straightforward style of prose and a tendency to state that which might be left unstated ('open woodlands can be thought of as an extension of woodlands. ...the trees are further spaced) detracts from what is otherwise a useful primer on the description of vegetation.

In summary, 'The Bush' achieves its goal of enabling enthusiasts to construct structural descriptions of plant communities, and for that I warmly recommend it and congratulate the author. Its wider applicability is however jeopardised by problems such as those outlined above.

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Renewal form in the
December *Field Nats News*

The Orchids of Victoria

by Gary Backhouse and Jeffrey Jeanes

Publisher: *The Miegunyah Press: Melbourne University Press, 1995. RRP* $59.95

Orchids have a magnetic fascination for both field naturalists and conservationists, as well as for those with even just a passing interest in bush plants. The interest in orchids is not at all surprising when one realises the fascination of the complex flower structure and coloration, the biological dependence of orchids on fungi, and what appear to be the strict ecological requirements of each species.

Gary Backhouse and Jeffrey Jeanes as authors and photographers have produced, with Melbourne University Press, a really comprehensive and informative account of the currently described 270 orchids of Victoria. I like this book and I think it will carry into the next century as the definitive account of our understanding of the Victorian orchid flora at the end of the 20th Century. The book is substantial, 1,350 g, 388 pages, firmly bound, resulting in a high quality production characteristic of the Miegunyah Press imprint of M.U.P.

Dr Jim Willis, unchallenged as Victoria's Botanist Emeritus, has written a thoughtful foreword tracing the 120-year history of orchid publication since Bentham's 'Flora Australiensis' (1873) which, incidentally, included only 61 orchid species at that time.

The main aims of this book are to provide information for the professional botanist and field naturalist and 'to enable identification of all the currently known or chid taxa in Victoria, and to provide an up-to-date review of the information available on each, including its natural history and conservation status'. Notes on cultivation and propagation have not been included and I, for one, am happy to endorse this approach and to applaud the emphasis on conservation.

The first 30 pages cover a range of topics which bring to the fore the essential nature of orchids; their floral and growth characteristics and ecological requirements, especially their dependence on fire and fungi. A short section on taxonomy and nomenclature is included and there is a discussion of orchid habitats. Finally, in this introductory section there is an important discussion of orchid conservation and the role of the 'Flora and Fauna Guarantee Act, 1988'. All these topics are important as background to the descriptive parts that follow.

My review has been written during one of the wettest and coldest winters we personally have experienced in the Yarra Valley and, for lack of material, I have not been able to work through any of the binary identification keys. These keys, I'm sure, will be great contributions and help in the use of this book. The key to genera is clear and for each genus the page, on which it can be found, is given. The genera, and species within them, are presented alphabetically and each species is described in a standard form at, one page to each.

From its size and quality of production, it is not intended as a field pocket book, although laws against orchid collecting will almost certainly see it taken into the field for working through the keys. Herein lies a conflict of purpose and the Publishers might well consider printing the keys as a supplement for field use. I estimate that this would come to a total of around 25 pages.

For each species the botanical name and authority is given, followed by at least one common name. The dynamic and evolving situation regarding the description and characterisation of orchid species is recognised by the inclusion for many species of a list of recent synonyms and similar or confusing taxa. Then follows a standard and complete botanical description of the plant. Months when the species can be found in flower are listed and there is a small map based on Churchill and Corona's 1972 map with known distribution indicated on the ten-minute grid basis. Next is a short statement of habitat and notes relating to any particular problems of identification and regional variation. Finally, there is a statement of the conservation status of the species.

Each species is accompanied by a colour photograph (10 x 6.5 cm) and in general these are of the highest quality and will be of great assistance in identification. On their own the photographs represent a major contribution to orchidology and a lot of hard work by the authors! Some presumed extinct species are represented with colour plates by W.H. Nicholls held in the collections of the library of the Royal Botanic Gardens, Melbourne. Identification and naming is clearly the main thrust of the book.

A legitimate question to be asked of orchid taxonomists is whether there is justification in splitting the Victorian representatives of the family into 270 species. Sometimes the differences between so-called sp ecies are most obscure and hard to recognise. Backhouse and Jeanes discuss this problem briefly on page 9. They draw attention to the existence of two main schools of thought regarding the definition of species; the 'lumpers' and the 'splitters'. They point out that the splitters tend to concentrate on the differences between the different taxa while the lumpers emphasise the similarities. The effect of these two approaches is for the splitters to recognise a larger number of species while the lumpers usually end up with significantly fewer species. I must admit to a natural tendency to side with the lumpers. Biologists have been debating the nature of species since before the time of Linneus and currently there is a broad, but not universal, acceptance of the concept of the 'biological species', viz. individuals of a morphological group which are capable of interbreeding and producing fertile offspring. Even if we accept the application of the biological species concept to the orchid flora of Victoria, the authors of this publication would still be faced with two substantial problems. Firstly, there is insufficient detailed information on the breeding biology of most of our orchid taxa to be able to determine their breeding compatibilities. Secondly, the authors, in this comprehensive account of the orchid flora of Victoria, recognise the need to include all the work done by systematists, both splitters and lumpers and including all the taxa which have been validly described. Individual orchidologists will need to apply their own criteria regarding the validity of any particular species.

As with all plants, pollination is a critical function in the life-cycle and most orchids have evolved very special floral structures and behaviour to attract insects in order to achieve pollination. There is, in my view, one serious sin of omission in this otherwise great book. On the dust-jacket it is claimed that the authors have included the most up-to-date review of the information on the biology and ecology of orchids and the authors repeat a similar claim in the Preface, viz. 'to provide an up-to-date review of the information available on each [species], including its natural history'. This, I must say, they have not done. I am aware of information in several publications covering research on Victorian orchids and published over the last decade which is not included in this work. There is no reference to the pollination studies of Dafni (on *Thelymitra antennifera);* the ecological and flowering studies by Cropper (on *Thelymitra epipactoides*) nor the comparative floral studies of Sydes (on *Thelymitra circumsepta* and *T. ixioides*). Slater has published fully on the floral biology and breeding system of *Dendrobium speciosum*, but there is no reference to this work. Adams and Lawson are regular and distinguished authors on the biology and flowering of the genus *Dendrobium* and there is little evidence of the inclusion of their work. Had these and other publications been included in the text there would have been a much stronger basis to support the claims made.

Notwithstanding these deficiencies, I believe this book will be a great success and will stand as a significant contribution to the taxonomic and conservation literature of the orchids of south-eastern Australia.

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Australian Beetles

by John F. Lawrence and E.B. Britton

Publisher: *Melbourne University Press 1994;*
192 pages, 15 colour and black & white plates; RRP $44.95

The first comprehensive book on Australian entomology was that of W.W. Froggatt in 1907. In 1926, R.J. Tillyard published his splendid 'Insects of Australia and New Zealand' and, with the exception of K.C. McKeown's wartime 'Australian Insects', this has served as the standard work for 45 years. In 1970, C.S.I.R.O. published the massive 'The Insects of Australia' providing a badly needed, authoritative text-book for professional entomologists and students alike. This has been updated and largely re-written in the second edition of 1991.

Unlike butterfly enthusiasts, who have been well catered for with a range of specialist books, coleopterists have had to make do with the appropriate chapter from the above mentioned texts until relatively recently. In 1980, B.P. Moore began 'A Guide to the Beetles of South-eastern Australia' as a series of fascicles issued from time to time with the *Australian Entomological Magazine*. Unfortunately, this seems to have petered out about half way through. Also in 1980, E.G. Matthews began publication of 'A guide to the Genera of Beetles of South Australia' which is expected to appear in 10 or 11 parts and is now about half way through. This work is profusely illustrated with clear line drawings and photographs and with easy to follow figured keys and is a joy to use. In 1987, T. Hawkeswood produced the handy field guide 'Beetles of Australia'.

The difficulty of producing a useful book about beetles lies in the enormous number of species, about 30,000 in Australia. The hope of finding a 'What Beetle is that' type of book whereby the reader hopes to identify any beetle down to species level is quite unrealistic. The best that can be hoped for is one that allows identification down to Family level and the book under review does this in the most comprehensive and authoritative way possible.

This book, which is based on the Coleoptera chapter of the C.S.I.R.O. 'The Insects of Australia', consists of three main parts:-

1. Introduction, covering Fossil History, Habitats, Collection. Anatomy, Immature stages and Biology. This excellent summary is entirely new and forms an up to date and succinct review of beetle biology.

2. Classification and Keys. This gives the latest classification of the family relationships listing 117 families occurring in Australia. Then follows a rather daunting set of keys to family or in many cases sub-family level for both adults (pp.38-57) and for larvae (pp. 57-78).

3. Treatments of each family individually.

This is followed by a considerably updated list of references and a comprehensive index.

The book is fully illustrated throughout with first class line drawings and six plates of scanning electron micrographs have been added to more clearly illustrate diagnostic characters. Two plates of coloured illustrations of some of the more striking beetles taken from 'Insects of Australia' and eight colour plates of photographs of living beetles add to the attractiveness of this book. The inclusion of a glossary of technical terms may have made this book more accessible to a wider range of readers. It is, at $45, good value and will be a boon to professional entomologists and advanced amateurs alike.

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Marie Allender

A Last Excursion

Marie Allender, aged 79, died on 27 September 1995 at a nursing home in Rosanna. A funeral service was held at St Kilda on Friday, 29 September and many members of The Field Naturalists Club of Victoria were present at the service to show their appreciation of Marie as a friend and a Club member who had given so many years of service to the FNCV.

With the passing away of Marie Allender the Club has lost a member known for 34 years to Field Naturalists all around Victoria as the Excursion Secretary of the FNCV.

Under her guidance excursions were conducted to areas of natural history interest throughout Victoria, every State of Australia, even to Norfolk Island, and to New Zealand. Over 500 excursions, from monthly day trips to extended annual tours, were arranged by her for the enjoyment of very many members.

Marie joined the FNCV in 1947 and became Excursion Secretrary in 1954. As an office bearer she also became a member of the Council and the two posts were carries out with zeal and regular attendance until her retirement as Excursion Secretary in 1989 and Councillor in 1994.

In 1967 the Club Treasurer decided to leave all the financial side of excursions to the Excursion Secretary and for nearly ten years Marie bore the total responsibility for arranging the finance as well as the excursions. When the Club again took over the financial position, Marie presented the Club with a bank balance of over $4,000. In recognition of her efforts for the Club, the Council established the 'Marie Allender Excursion Fund'.

Marie was made an Honorary Member of the Club for her work as Excursion Secretary in 1965 and, in 1985, a Presentation of a Silver Tray was made to Marie for THIRTY YEARS as Excursion Secretary, a remarkable achievement.

Many members would not know that Marie suffered the loss of a kidney in her younger days and in her later years, while Excursion Secretary, lost the sight of one eye.

Marie was employed at the National Herbarium as a technical assistant until her retirement, and this gave her a very active interest in the Botany Group, in arranging the Group excursions and in the displays of botanical specimens at Group meetings and Nature Shows.

The name of Allender will live forever in the name of a plant, ***Olearia Allenderae*** **J.H. Willis spec. nov.**, found only in a small tract of land cn Wilsons Promontary. Dr J.H. Willis wrote that he had pleasure in naming this graceful plant after its discoverer Miss Marie Allender (of the Melbourne Herbarium staff) who has advanced our knowledge of the Victorian flora by several other noteworthy discoveries.

D.E. McInnes

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Members include beginners as well as experienced naturalists.

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The Victorian Naturalist

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MEMBERSHIP

Members receive *The Victorian Naturalist* and the monthly Field Nat News free. The Club organises several monthly meetings (free to all) and excursions (transport costs may be charged). Research work, including both botanical and fauna surveys, is being done at a number of locations in Victoria and all members are encouraged to participate.

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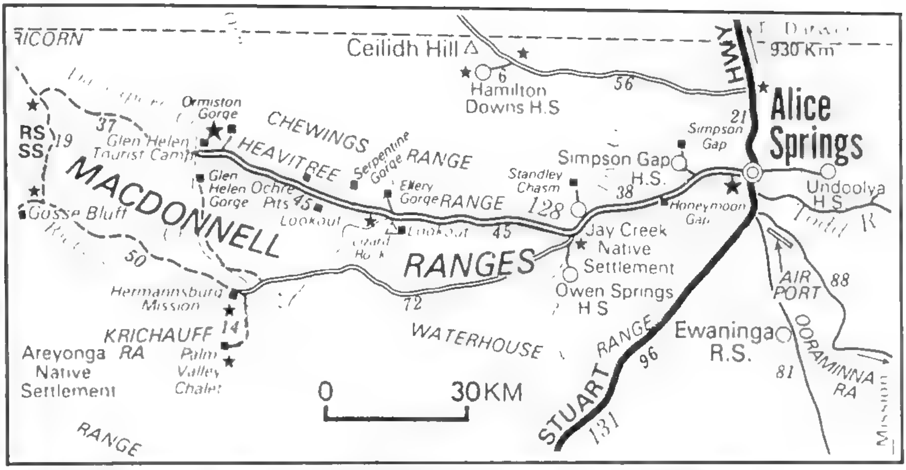

Fig. 1. Map showing location of popular places in the Western MacDonnell Ranges.

fold in the Heavitree Quartzite can be seen, produced by the intense lateral pressure that occurred during the ancient period of mountain-building. Thompson (1991) considers that Ellery Creek Gorge may lie along a north-south fault line which has slightly displaced the quartzite.

From Ellery Creek Gorge downstream for about 8 km one can see a very interesting sequence of sedimentary rocks exposed along the banks and in the bed of Ellery Creek. Indeed, a thickness of about 6,000 m of sedimentary rocks can be inspected, including sediments laid down beneath the sea during the Cambrian period, the Ordovician period and later periods of geological time. The rocks, which include sandstones, shales, limestones and conglomerates, are fossiliferous, and the various fossils found in them have been of use in dating the sediments.

Serpentine Gorge is approximately 20 km to the west of Ellery Creek Gorge. In fact, it has been formed by a stream that is a tributary of Ellery Creek. Two gorges actually occur here where the south-flowing creek cuts through two ridges of Heavitree Quartzite. There is a prominent fold in the strata between the two ridges. At the upstream site at this locality, the very narrow gap indicates that the creek has eroded along a nearly straight, vertical joint.

At Ormiston Gorge, about 24 km north-west of Serpentine Gorge, there are sheer 200 m cliffs of pinkish quartzite. The deep, narrow gorge has been eroded by Ormiston Creek, a tributary of the Finke River. The geology here is very complex with much folding and overthrusting of the rock strata.

Glen Helen Gorge has been eroded by the Finke River through a sandstone of Cambrian age known as the Pacoota Sandstone. The shape of the Gorge has been controlled quite markedly by jointing in the rock, the joints (parting-planes) having acted as zones of weakness to erosional forces. The layers of sandstone that were originally horizontal have been turned up on end during the upheavals that produced the MacDonnell Ranges. This popular place is approximately 125 km west of Alice Springs.

Standley Chasm is a narrow chasm which has been formed by erosion in quartzite known geologically as the Chewings Range Quartzite (Fig. 3). This quartzite is of early Precambrian age and is probably about 2,000 million years old. A vertical dyke of an igneous rock called dolerite here was intruded into Chewings Range Quartzite. Dolerite is much less resistant to weathering and erosion than quartzite and a south-flowing creek has almost completely eroded away this dolerite dyke leaving vertical quartzite walls; this is now Standley Chasm. The relatively narrow, parallel-sided ig-

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